RAM BAGH, PATIALA

HOW AND WHY

To

All who Wonder Why

THE STRONG MAN OF THE AGE OF STEEL

THE MAN WITH THE HAMMER

HOW AND WHY

QUESTIONS, ANSWERS, AND EXPLANATIONS

Being Volume 5 of

THE CHILDREN'S TREASURE-HOUSE

A Companion to the Children's Encyclopedia

Edited by Arthur Mee

Editor of the Children's Newspaper

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One Hundred Questions

ABOUT AN AEROPLANE

THE aeroplane will change the world. No man can imagine the things that it will do. Think of only one of a thousand ways in which it will transform the conditions of life as we have known them.

FOR generations men have sought the Poles and explored the great white world around them. They have gone out to that world of ice and dragged tons of stuff about with them by hand or with the help of dogs, and how many expeditions have perished in the effort!

IT will never be again, for the aeroplane will fly to the Poles and will carry there whatever materials the explorer wants. It will set up depots every hundred miles, with telephones and telegraphs, and the day will come when it will open up these fields of ice to civilisation, so that even power may come from there in time, for there is coal at the Poles, and men will turn it into electricity and bring it home in little storage batteries.

THERE is no end to the dreams of the aeroplane, and we must all know something about it. Here are a hundred things that we should know.

What is an aeroplane's life in miles?

It varies considerably, owing to varying conditions of flight, but perhaps fifteen or twenty thousand miles may be taken as an average.

What are its most vulnerable points?

The petrol-tank, the engine, the propeller, and the bracing wires.

What does an aeroplane weigh?

The smallest aeroplanes weigh six or eight cwt.; the largest eight tons.

How long does an aeroplane take to make?

As a rule, about 4000 man-hours. That is to say, 100 men would take 40 hours to build an aeroplane.

What does an aeroplane cost to build?

A small aeroplane at the time of writing costs about £500. A big Handley Page may cost £12,000 or £20,000.

How fast does the propeller go?

The speed of propellers varies from 900 to 1500 revolutions a minute. From 1100 to 1200 are common speeds.

Can seaplanes land on land?

Some seaplanes used to be fitted with wheels so that they could alight on land. A skilful pilot could bring down an ordinary seaplane on good ground, but he would probably damage the machine.

Can an aeroplane turn in its own length?

Small fast aeroplanes can turn very quickly, and they have been known to skid round on their vertical axis—that is to say, within their own length.

How far can an aeroplane fly?

The distance can be calculated by multiplying its speed per hour by its petrol-tank capacity. Thus, a 70-mile-an-hour machine with five hours' fuel capacity can fly 350 miles.

How high can it go?

The greatest record for height, held by an American, is 36,020 feet.

How fast can an aeroplane go?

The greatest ordinary speed is from 130 to 140 miles an hour. Exceptional machines go faster. The average speed is between 100 and 120 miles an hour.

How slow can an aeroplane go?

About half its top speed is probably the slowest rate at which it can fly.

What weight can an aeroplane carry?

This depends entirely on its size. A small single-seater might carry 800 pounds, including pilot and fuel. The big Handley Page aeroplane the editor of this book went up in can carry eight tons in addition to its own weight.

Is automatic stability possible?

It is possible to make an aeroplane stable, but, like a lifeboat on that principle, it is slow and difficult to steer.

Is the balance of an aeroplane ever upset?

The balance of an aeroplane can easily be upset by the wind, or by carelessness or lack of skill by the pilot.

Can an aeroplane rise vertically?

Not in relation to the air, but it can do so in relation to the ground when facing a very strong wind.

That is to say, if the wind is pressing it backwards the actual rise may be in a straight line, as it were, as if the machine were not moving forward at all.

Can an aeroplane stand still?

An aeroplane cannot stand still in relation to the air, but if it is going against a very strong wind it may do so in relation to the ground.

Can a man fly upside down?

It is possible for some aeroplanes to be flown a short distance, sometimes a mile or two, upside down. They generally lose height while doing this.

How long can a man fly without stopping?

The longest non-stop flight on record was made in 1920 by two Frenchmen, who flew 24 hours 19 minutes without stopping. An ordinary aeroplane cannot, as a rule, fly for more than six or eight hours.

Does an aeroplane use up its exhaust?

The exhaust is usually run to waste, although occasionally some of it is used to warm the carburetter.

Does an aeroplane make its own electricity?

Magnetos make the current for ignition. If wireless, headlights, or electrically-heated clothing is required, a dynamo is often driven off the engine. Sometimes batteries are used.

Is an aeroplane bullet-proof?

The ordinary aeroplane is not bullet-proof save for the seats of the crew. Special low-flying aeroplanes are frequently bullet-proof for the first half of the fuselage.

Could an aeroplane be made quite fire-proof?

This is just possible, but it would have to be made entirely of metal, and petrol could not be used. A new type of motor—driven perhaps by liquid air—would have to be invented.

How does a pilot know the way of the wind?

By looking out for bending trees or smoke from chimneys, or watching his speed relative to the ground, from which he can work out wind-resistance.

How does a pilot know when he flies too slowly?

The aeroplane has an instrument called an air-speed indicator, worked by wind-pressure, with a danger-mark.

How does a pilot know if he is flying level?

By watching the horizon, or by looking at an instrument called an inclinometer, working like a spirit-level.

How does a pilot know how high he is?

There is an instrument called a barograph, which is affected by the diminishing air-pressure, and so shows the pilot on a dial how high he is.

How does a pilot know how much longer he can fly?

As a rule there is a gauge on the petrol-tank, and by calculating how many miles he can fly to a gallon, and multiplying that by the number of gallons left, he can tell how long he can go on flying.

How does a flying man keep warm?

By wearing heat-proof and wind-proof garments, usually of leather lined with fur, with thick woollen underclothing, and fur-lined boots, gloves, and hat. Sometimes his clothing is kept artificially heated by fine insulated wires which run through them and communicate with an accumulator.

What does a pilot take up with him?

Most instruments are usually built into the aeroplane, but a pilot will carry maps, barograph, compass, tool-kit, thermos flask, food, a few engine-spares, a first-aid outfit, and a supply of oxygen if he is to fly high.

Does a flying man hear anything on earth?

When the engine is running very heavy gunfire may be heard. When the engine is stationary the noise of the wings and wires rushing through the air makes it impossible to hear any ordinary noise.

Can two men in an aeroplane hear each other speak?

Yes, if they shout in each other's ears or have proper telephones. It is impossible, however, to hear one's own voice. The American aeroplanes in the war were equipped with an "audion," enabling them to hear the voice above the noise of the machine.

Must a pilot keep his eyes fixed in one place?

Not if he knows the country, or is flying by prominent landmarks. If he is flying by compass he must keep his eyes fixed on a point ahead to note if the machine is drifting.

How does a pilot see at night?

Even on the darkest night it is possible to see prominent outlines, such as rivers and roads. The instrument-board of the machine is lighted with electric lamps. Landings are made with the help of flares.

What happens when a pilot loses his way?

He will do his best to identify prominent landmarks with his map, try to ascertain his direction by the sun if his compass goes wrong, and, in the last resort, land and ask where he is.

How near can two aeroplanes fly?

Within two inches of each other if the pilots are skilful and daring enough. Pilots during the war frequently got within ten feet of one another.

Can men come down from aeroplanes in parachutes?

The first parachutes used from aeroplanes were employed in 1913. Now their use is quite common, and they are invaluable in case of accident.

Can flying men send wireless messages?

Yes. Many aeroplanes are fitted with wireless transmitting sets.

Can flying men receive wireless messages?

Yes. Aeroplanes can be fitted with receiving sets. Flying men were able to send messages long before they could receive them.

Can flying men speak by wireless telephone?

The wireless telephone is quite possible in aeroplanes, and is being rapidly developed. The voice from the clouds is very clearly heard.

Is an aeroplane ever broken to pieces in the air?

Aeroplanes have frequently broken to pieces, either as the result of enemy fire, faulty construction, injuries due to bad landings, or through the pilot "stunting" excessively.

How can we distinguish a big aeroplane from a little one in flight?

It is difficult to distinguish the size of aeroplanes in the air, because a little one low down will look as big as a large one high up. When both look the same size the machine which seems to go faster is the smaller one.

How many people can an aeroplane carry?

The greatest number taken up so far is 41.

What are the wings made of?

Generally the wings are made of fine linen, which forms the covering also of the body and contrôl surfaces.

What is meant by the factor of safety?

The factor of safety in an aeroplane is the ratio between the load placed on any part of an aeroplane and the strain at which it will break.

What does horse-power mean?

One horse-power is the power required to lift 33,000 pounds one foot high in one minute.

What is the backwash of an aeroplane?

The stream of disturbed air behind an aeroplane, created by its passage and by the action of the propeller blade.

How fast can aeroplanes climb?

Before the war it was thought well if an aeroplane could climb at the rate of 500 feet per minute up to 5000 feet. Now it is not rare for an aeroplane to rise 15,000 feet in ten minutes.

What is a nose-dive?

The controlled fall of an aeroplane in a more or less vertical position, called by the French "vol pique."

What is a vertical engine?

An engine with cylinders arranged in a straight line along the top of the crank-case, as in motor-cars.

What is a Vee engine?

An engine with cylinders arranged in two rows along the crank-case, the rows being set at an angle of 45, 60, and sometimes as much as 90 degrees.

What is a water-cooled engine?

An engine kept cool by water circulating through water-jackets.

What is a water-jacket?

A pocket encircling the sides and top of an aero engine through which water passes to cool the cylinders.

What is a monoplane?

An aeroplane with only one pair of main planes, one wing being placed on either side of the body.

What is a biplane?

An aeroplane with two pairs of wings, lower planes and upper planes. This is the most common form.

What is a triplane?

An aeroplane with three sets of wings, one above the other.

What is a quadroplane?

An aeroplane with four sets of wings. There have not been many of these.

Can an aeroplane be made self-starting?

Yes, it is generally done by means of a compressed-air bottle arranged to inject air into the cylinder.

What is the streamline?

The streamline is the line of the body of the aeroplane, designed to offer the least possible resistance to the air. It should avoid sharp corners, so as to present a rounded head to the air, and taper off to a point at the rear.

What is the "load" of an aeroplane?

We mean by the load of an aeroplane the weight that it carries in addition to its own weight.

What are drift-wires?

The drift-wires are wires used in the internal structure of the wings to prevent horizontal air-pressure from folding them backwards.

What is a cowl?

The metal bonnet of the engine and the covering of the end of the fuselage.

What is dope?

Dope is a special varnish, generally made from cellulose, and used for tightening the fabric of the wings.

What is the boss?

The boss is the metal hub on which the propeller is fixed.

Does a raindrop dint the propeller?

Heavy raindrops can readily dint a propeller, and a violent shower may remove all the varnish, or may even fray the edges.

Why does rain not cut the wings?

At the most an aeroplane's wing does not cut the air at more than 250 feet a second. An eight-foot propeller, turning 1200 times a minute, cuts the air at 500 feet per second.

Is the wind ever too strong for an aeroplane?

The wind is seldom too strong for an aeroplane to fly, but it may prevent it from reaching a required destination by slowing the machine, or even by blowing it backwards.

What wind-pressure can an aeroplane stand?

If properly built, it will stand any pressure it can possibly encounter.

Is it dangerous to fly in the clouds?

It is dangerous to fly in clouds because if the machine should start spinning or diving the pilot may be unable to understand what is happening. Collisions, also, are possible.

Can a man fly in rain?

Flying in the rain is very unpleasant, as it stings the face, obscures the goggles, and makes observation difficult. It may fray the propeller, but it does not affect the aeroplane much except to reduce its lift slightly.

What happens to an aeroplane in a mist?

Considerable danger exists of the machine hitting an obstruction on the ground. The pilot will generally try to fly up above into clear country.

What happens to an aeroplane in a thunderstorm?

It is not on record that an aeroplane has been struck by lightning, although sparks have sometimes come from the machine. The wind and rain in thunderstorms are often violent, and the pilot might lose control.

Is it easier to land on the earth or on the sea?

Generally it is easier to alight on the land. The ground is always still and water is very hard. Those who dive will understand this.

How much petrol does an aeroplane carry?

An ordinary aeroplane carries about sixty or seventy gallons. A very big machine, such as the 1400 h.p. Handley Page, may carry as much as a thousand gallons.

How far does an aeroplane go on a gallon of petrol?

The distance travelled by an aeroplane on one gallon of petrol depends on its type and speed. A 100 h.p. aeroplane which could fly at 70 miles an hour would travel about eleven miles to a gallon.

What happens if petrol runs out?

The engine stops and the pilot has to come down. Usually a small reserve tank is carried which will enable the machine to fly a few extra miles.

What happens if the engine stops?

The pilot must start gliding, select the best alighting ground, and make for it. He is in no particular danger if a good field is within reach.

Has a pilot a special compass?

The compass works on the usual principle, but is often specially constructed so as not to be affected seriously by the great vibration of the engine and the swinging of the machine.

What is a direct-lift machine?

A type of flying machine intended to mount vertically upwards, which has never been made to work.

How many parts has an aeroplane?

Machines vary very much and many parts are duplicated. Probably we may say from 2000 to 3000.

What is a main spar?

A strong boom running from one end of a wing to the other, which supports the whole structure. There is usually a front and a rear main spar.

What is the joy-stick?

The popular expression for the control lever with which the pilot works the elevator and ailerons.

What is a tail-boom?

A tail-boom is a long spar—usually one of four—which support the tail-planes of the Farman and F.E. type biplanes, which have no long, enclosed body, or fuselage.

What is a longeron?

A French word used to describe the long booms which make up the body of an aeroplane.

What is a tractor biplane?

A biplane where the air-screw, or propeller, is at the front of the fuselage. This is so with nearly all aeroplanes.

What is a "pusher" biplane?

A biplane of the Farman type with a propeller at the back of the nacelle.

What is a cabane?

The framework, generally of steel tubing, which supports the centre of the upper wing of a biplane.

What is a hydro-aeroplane?

A hydro-aeroplane is an aeroplane fitted with floats enabling it to start from and alight upon the water, a makeshift arrangement which may be interchangeable or temporary.

What is a flying boat?

A flying boat is an aeroplane constructed with a big boat-shaped hull which makes it possible to float upon, start from, and alight on the sea.

What is an aileron?

Little hinged flaps at the ends of the planes, which the pilot can lift or depress by sideways movements of the control lever, in order to balance the aeroplane sideways.

What is the elevator for?

The elevator is the hinged portion of the tail, and its tilting causes the aeroplane to rise or fall.

What are the wings for?

The wings cut the air at an angle, and so impart lift to the aeroplane, much as the wings of a kite do.

What does the tail of an aeroplane do?

The tail works very much on the same principle as the tail of a bird, promoting stability and controlling rising and falling and steering.

What is a fuselage?

The fuselage is the long enclosed body of the ordinary aeroplane, which in front houses the engine and crew and at the rear supports the tail-planes.

What is the rudder for?

The rudder is a hinged portion of the tail arranged vertically, its movement to one side or the other causing the aeroplane to turn correspondingly.

What is a nacelle?

The nacelle is a short car used on Farman and F.E. type biplanes, which have no fuselage.

Why has an aeroplane wheels?

It is necessary for an aeroplane to have wheels because in starting and landing the machine runs for some distance along the ground.

What does the propeller do?

The propeller, rotated at high speed by the engine, draws the aeroplane through the air at sufficient speed to allow the wings to lift the machine.

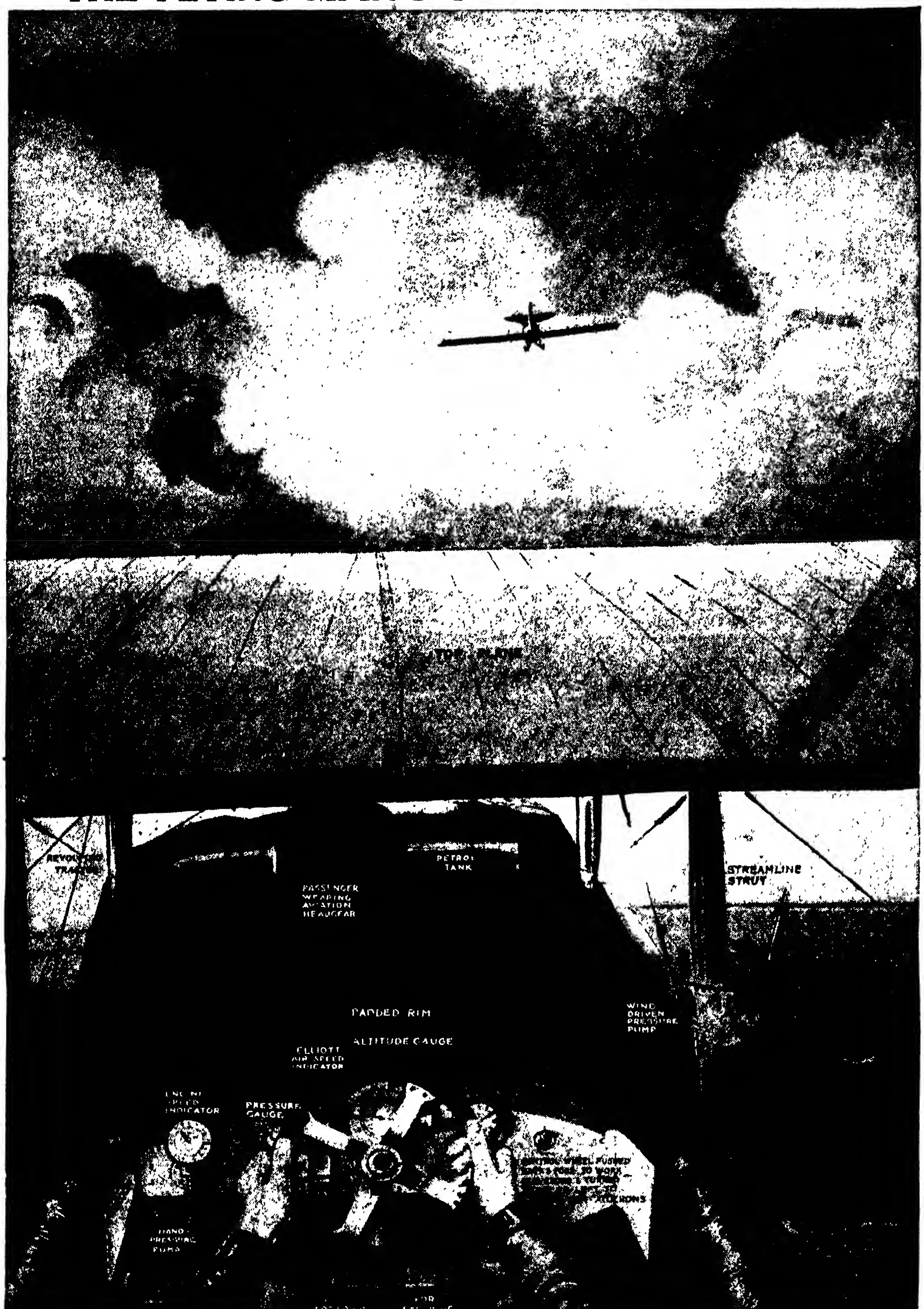
What is banking?

Banking is the lateral tilting of an aeroplane when turning. The quicker the turn the greater the bank.

Who flew the first aeroplane?

Orville Wright, the brother of Wilbur Wright, at Kill Devil Hills, Dayton, Ohio, on December 17, 1903.

THE FLYING MAN'S SEAT IN THE CLOUDS



IN FRONT OF THE FLYING MAN AS HE SITS IN THE AEROPLANE—THE MARVELLOUS MECHANISM CONTROLLING THE FASTEST MOVING MACHINE ON EARTH

What You Should Know

ABOUT AN AEROPLANE

THE world is changing fast before our eyes. The old order changes, giving place to new,

And God fulfils Himself in many ways,
Lest one good custom should corrupt the world.

And never did things change so fast as in these days. Your grandfather's father may have seen a little steamship struggling along a canal or lying abandoned on its banks. Your grandfather saw a railway train which came pushing proudly into the world at twenty miles an hour. Your father saw a motor-car riding the roads like a giant of power at a mile a minute when the driver let it go. But you who are at school have seen a thing that clever men and wise men hardly dreamed of years ago; you have seen a thing that wise men scoffed at, even when you were born—you have seen a motor-car riding through the clouds.

I suppose that in all the history of the world there has been hardly anything equal to that. Think of it in any way you like, and it must seem to you a miracle. Throw a stone up into the air, and it falls down; throw a stream of water up, and it comes back to earth; throw a feather up, and, although it floats a little while on the wind, it glides back to the solid earth, and lies there like the stone.

They fall, all of them, by what we call the law of gravitation, which means that the earth pulls everything towards its centre. A pebble rolls down a hill; water runs to the lowest point. It is the pull of something in the mass of the earth that draws all things towards it as a magnet draws a needle. It will pull a flint out of a chalk bank if we give it time; it will pull down an overhanging tree if it is left long enough without support. This universal power of matter to attract other matter to it, the larger mass attracting a smaller, is one of the mysteries that no man understands.

And yet, as I sit writing this on a hilltop in Kent, a motor-car flies past a mile above my head, so high that it looks like a bird, so beautiful that it looks as if Nature herself had made it, so confident of its power as it passes out of sight that it thrills a man to feel that he belongs to the race that made it. Now it is a speck. Soon our eyes will lose it, but we know that there is a man up there, and that he is going on and on and on until he sees the sea, and on again until he sees the stricken land of France, and on again until he sees the long, thin khaki line where stand our men immortal, saving the human race.

It is not the first kind of thing that has taken a man up in the clouds. There have been balloons and there are airships, but the flying motor-car which we call an aeroplane is far more wonderful than these. The balloon and the airship are lighter than air, and they sail on the sea of air on which we live as easily as a ship sails on the sea of water in which the fishes live. Remember that air is something very real. It is so thin that we cannot see it, so fine and colourless that we can hardly believe it is there. It is as real as the chair you sit in, and it has weight as water has, strength as water has, power to bear things on it as water has. When you fly a kite it is sailing on air; it rests on the air beneath it, which is trying all the time to push it up.

A thing that is lighter than the bed it lies on cannot sink into its bed. Put a feather on a feather bed and the bed will remain undisturbed, but put a piece of iron there and the bed will give way to it. It is so with water. A feather is lighter than water, and will float; a piece of iron is heavier than water, and will sink. But if you take a basin made of iron and rest that on the water, the basin will float because it has much more water to rest on and is not so heavy as its bed.

And so, if you beat a mighty sheet of iron into an enormous basin, it will still float, because, as long as it is filled with air and rests on an enormous stretch of water, it is lighter than that great body of water. Even if you put heavy engines in this iron basin, and fill it with people and thousands of tons of all sorts of things, it will float like paper on the sea, so smoothly that sometimes it will go a thousand miles, and a glass of water would not slip off a table with the rocking.

Why an Iron Ship Sails on Water and a Wooden Ship on Air

So an iron ship sails, though it weighs a thousand tons. So an airship sails with its heavy engines, with its crew of perhaps twenty or thirty men, all held up by an enormous bag of gas, which, even with the load that hangs on it, is lighter than the bed of air it rests on. The airship and the watership have gravitation on their side—that is to say, they rest on something heavier than themselves, and gravitation does not pull them down; they sink naturally into their bed. But the aeroplane has gravitation against it, and it must fight all the time for its life.

How does it do it? How does the great weight keep up there, heavier than the little air it rests on?

There are many ways in which we could explain it, but most of them are difficult to understand unless we go into the laws of physics and into mathematics, but one of them is simple. Throw a stone as hard as you can, and, though gravitation pulls it down, it will fly through the air as long as the force you put into it remains with it; then it will fall.

The Power We Put Into a Stone When We Throw It

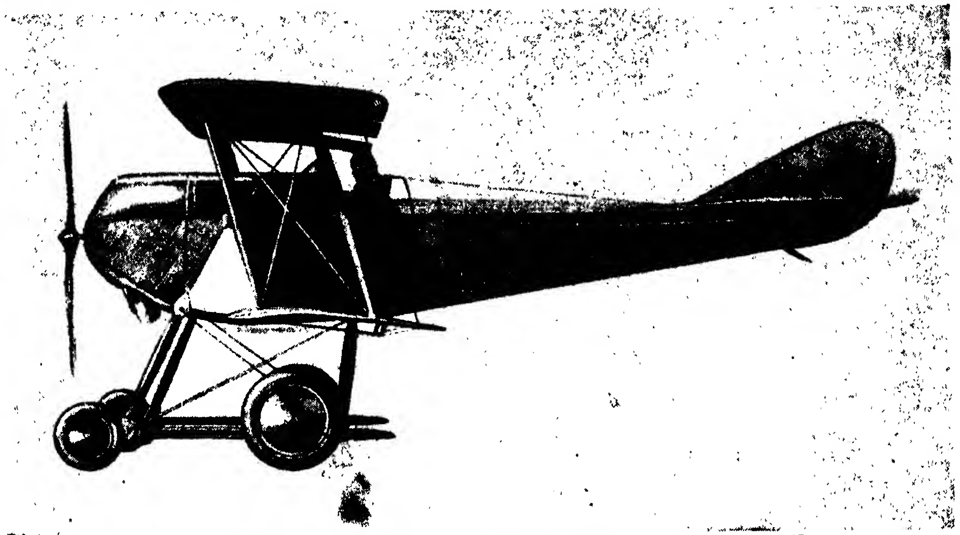
But suppose the force you gave the stone should last a minute, or an hour, then the stone would go on and on, because the force that drove it straight would be strong enough to tell against the force of gravitation that was pulling it down. There is no reason at all why a stone should fall, except the pull of the earth; and if a stronger pull or push sends it another way it will go that way.

Well, the engines of an aeroplane give it the power that we give to a stone, and they keep it going all the time. They turn a screw, and the screw draws the flying chariot behind it. Take a screw and drive it into a piece of wood, and it will carry into the wood anything that is fixed behind it. Put a big screw on a ship and drive it into the water, and it will carry through the water the ship and all that is in it. Put a screw in an aeroplane and drive it into the air, and it will carry through the air whatever is fixed behind it.

The propeller is the screw. It screws its way through air as real as wood and water. Run as hard as you can, and you will feel the air is resisting you. On the calmest day you can make a little gale of wind for yourself and run till you feel that you are running against a wall. The air resists the propeller of an aeroplane, but it screws its way exactly like the screw of a ship or the screw in a piece of wood, and the aeroplane must follow where the propeller goes.

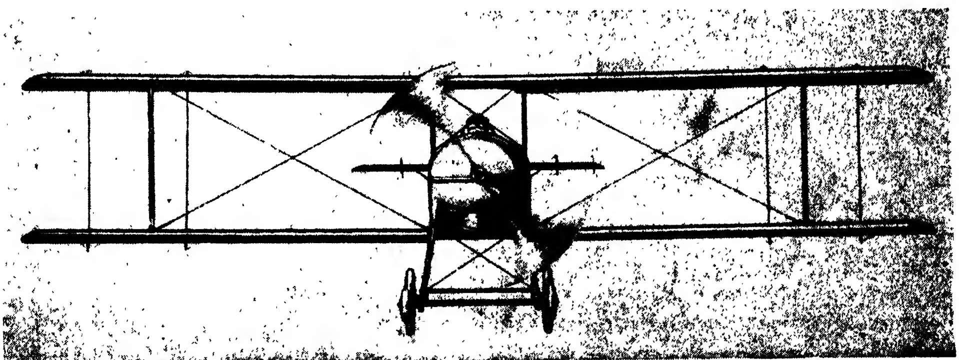
The Reality of the Air and the Highway in the Skies

Remember that air is real, that it is matter as much as a stone is, and the thought of an airship riding on it, or an aeroplane screwing its way through it, will be easier for you to understand. The flying motor-car cannot stand still like a ship that rides on its great air propeller, but as long as its engines drive this propeller round it will screw its way through, and the marvellous things that control its wings will send it up into the clouds or bring it slowly back to earth. Its way is not always smooth. It is bumpy at places, like the Dover road in war time; there are hills and dales for it to cross, and suddenly it may fall a hundred feet. But ninety-nine times in a hundred it will right itself with perfect ease; and the control of man over his new highway has become one of the greatest human triumphs of all time.



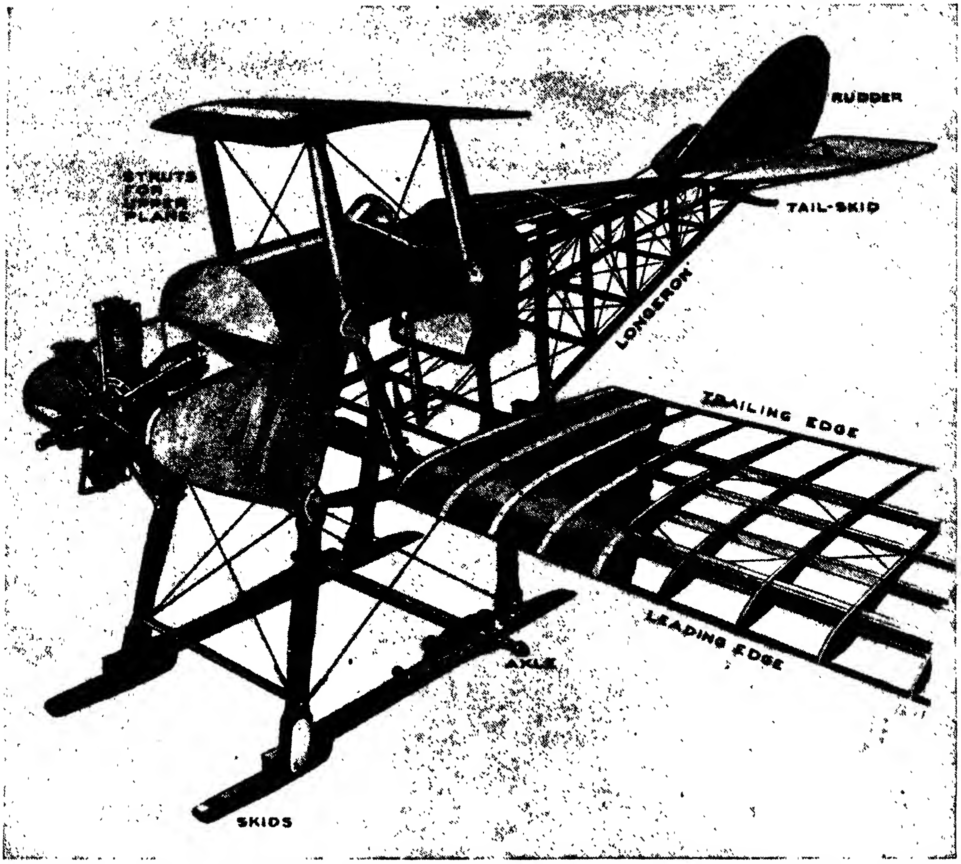
1. THE GRACEFUL LINES OF THE AEROPLANE AS IT FLIES LIKE A BIRD

One of the things we notice as we compare early ships with modern ships, early trains with modern trains, early motor-cars with modern motor-cars, is that the outline becomes more graceful all the time. It is not merely that men are trying to make these things look more beautiful, but that they find out by experience what are the best lines possible for these vehicles. A round stone will glide through the air better than a square one; the air resists it less. And so what are called the stream-lines of an aeroplane are very important. As the aeroplane presses the air forward, the air behind is drawn backward to exactly the same extent. One of the laws of motion that Sir Isaac Newton discovered is that the action of a moving thing causes an equal reaction, and it is this law that works when an aeroplane, pushing its way forward, finds itself pulled backward by suction behind it. The problem is to enable the air pushed in front to flow away behind the machine as smoothly as possible, and so the parts of the aeroplane are all rounded and tapered off finely to enable this to happen. This picture of an aeroplane in motion shows how easy and graceful the stream-lines are as they move through the air.



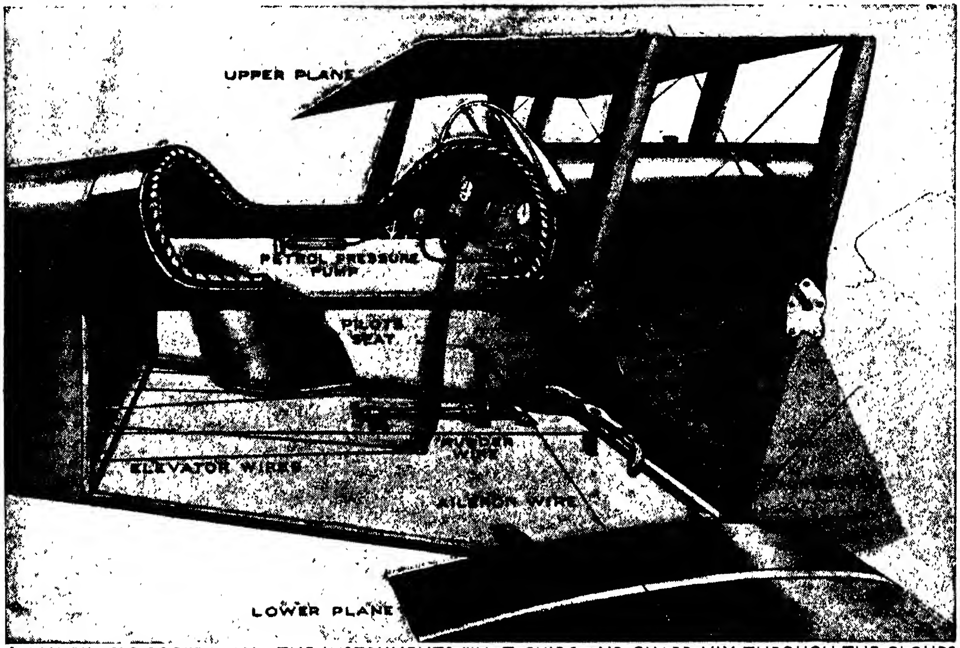
2. THE AEROPLANE COMES TOWARDS US—THE FLYING MOTOR-CAR LOOKING ALMOST LIKE TWO BLADES OF CORN

Here the aeroplane is flying directly at us as we look at it, the propeller being practically invisible owing to the high speed at which it is revolving. We see how splendidly constructed the aeroplane is for gliding through the air so as to meet as little resistance as possible, and consequently to achieve the highest possible speed.



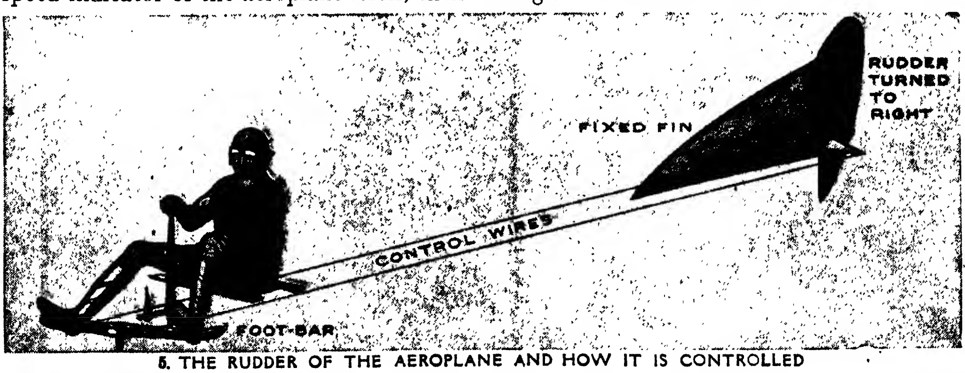
8. THE SKELETON FRAMEWORK THAT HOLDS THE AEROPLANE TOGETHER—THE STRUCTURE OF A BIPLANE

The structure of the aeroplane is shown clearly in this skeleton of its principal parts. The little Gnome engine is fixed into a steel frame in front of the body, and the little projecting shaft in front of it carries the propeller. The long central body of the aeroplane is here uncovered, and we see how it is built up of long rods, called longerons, which taper off towards the tail-end and are joined at the rudder. They are held in their places by cross struts fastened on with flat steel clips, and gripped by wires fastened from corner to corner, so that the whole body, called the fuselage, is put together in the style of a somewhat flexible box-like girder. Part of one of the wings—also called planes or aerofoils—is given to show how they are made; they are generally made so that they can be removed for convenience. The upper planes are fixed to the section over the pilot's seat. The spars and ribs of the wings give great strength with flexibility. The spars run the whole length. The whole framework of the wings and the fuselage is covered with linen, which is varnished in order to present a stiffer surface to the air. It is proof against rain and snow and oil and petrol. It is important that the wings should not be flat, and, as the word "plane" means "flat," it is really a bad word to use. The wings are really curved at the front edge, and they are fixed at an angle so that the air can get under them to lift the machine. As the wings press the air in front of them, the compressed air-wave flows back to find room, and the hump of the curve attracts the air-wave upwards. One result of this is to create a vacuum over the large, flat surface of the plane behind the hump, and thin strips of cane are fixed across the top of the plane to help the fabric to resist this suction.



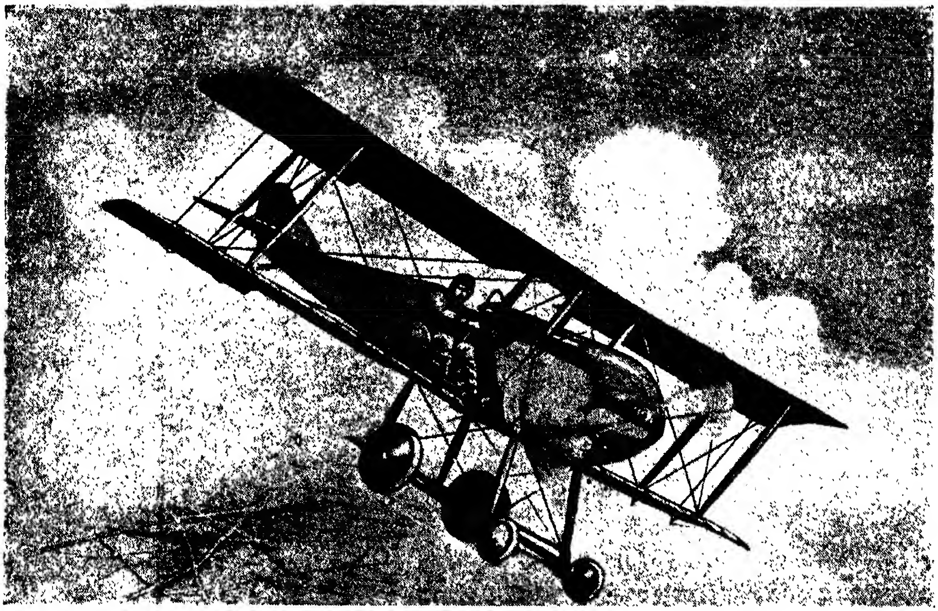
4. THE PILOT'S COCKPIT AND THE INSTRUMENTS THAT GUIDE AND GUARD HIM THROUGH THE CLOUDS

In the pilot's cockpit. Here a man sits and flies for his life. All that the world means to him depends upon these handles and wires about him. Beside him, at his fingers' ends, is the little pump for keeping up pressure in the petrol tank, and just in front of this is the lever controlling the sparking apparatus for starting or stopping the engine. In front of this is the speed-indicator for the engine. On the instrument-board in front is a clock on the left, then the speed indicator of the aeroplane itself, then the petrol and lubricating oil gauges, then the altimeter for showing the height, then the compass. In front of the pilot is the all-important control-lever, which moves forwards and backwards and from side to side. Wires attached directly to it control the rise and fall of the aeroplane; its forward and backward movements control the elevators which govern the ascending and descending; and its side to side movements cause the lift and dip of the wings. The foot-bar controls the rudder.



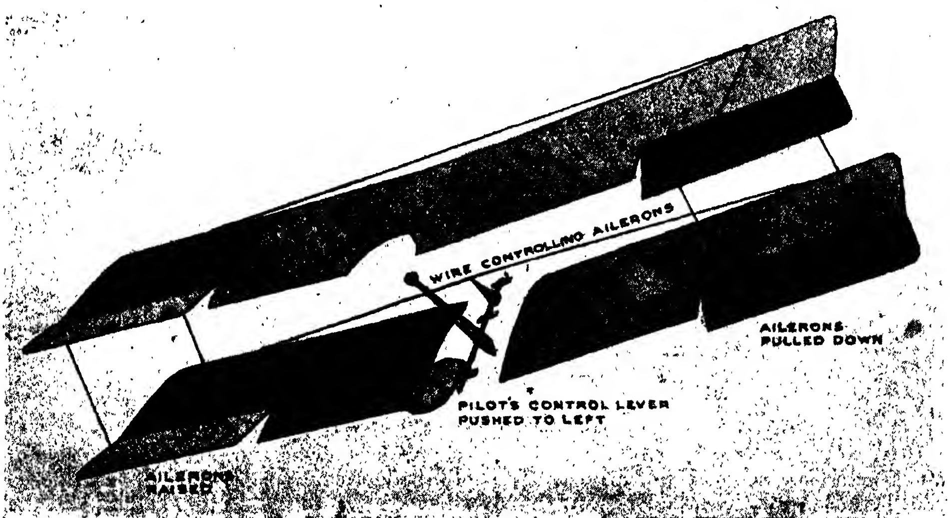
5. THE RUDDER OF THE AEROPLANE AND HOW IT IS CONTROLLED

Here we see the working of the rudder, which acts like the rudder of a boat. The pilot here is pushing the rudder-bar with his right foot, so that the rudder turns to the right. The air-pressure on the right side of the rudder causes suction on its left side, so that the tail fin moves to the left, and the nose of the aeroplane turns to the right.



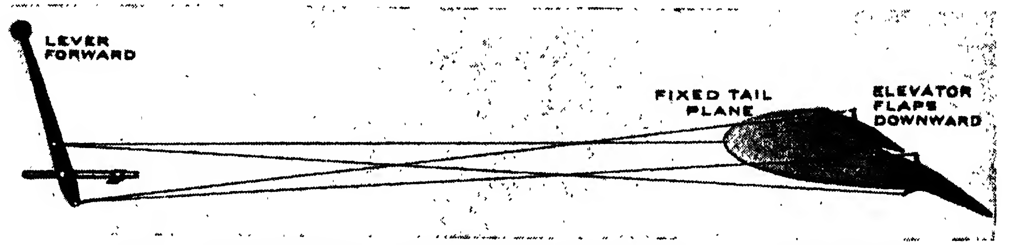
6. HOW THE AEROPLANE TURNS ROUND—A PILOT "BANKING"

We have not yet realised how adaptable the aeroplane must be to the call of the wind. It must be fine and strong in all its parts, it must be smooth and easy against the air, it must be rigid or flexible, as the need may be. At each end of the wings is a movable flap such as we see in this picture. They are called ailerons, and their business is to act as rudders to the neighbouring parts of the wing. They are worked by the side to side motion of the control-lever, and they are all-important in the difficult business of what is called "banking" in the air. As the aeroplane



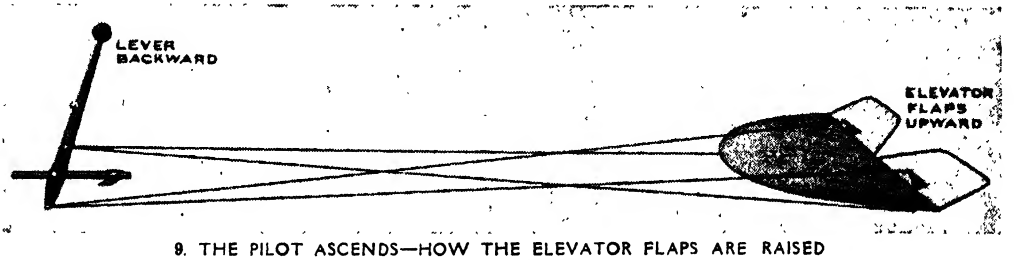
7. THE METHOD OF CONTROLLING THE WINGS IN BANKING TO THE LEFT

turns to the left, the right wing travels faster than the left, and so receives more lift or upward pull from the vacuum above it. The right wing therefore rises higher, while the left wing drops. The machine is " banking to the left." If the bank is too steep the machine will side-slip inwards, and it is in emergencies like this that the movable flaps on the wings come to the pilot's aid. A good pilot finds his position instinctively, but the most skilful pilot may be taken unawares by a sudden gust of wind, and at such a time he is thankful to the man who first thought out the aileron.



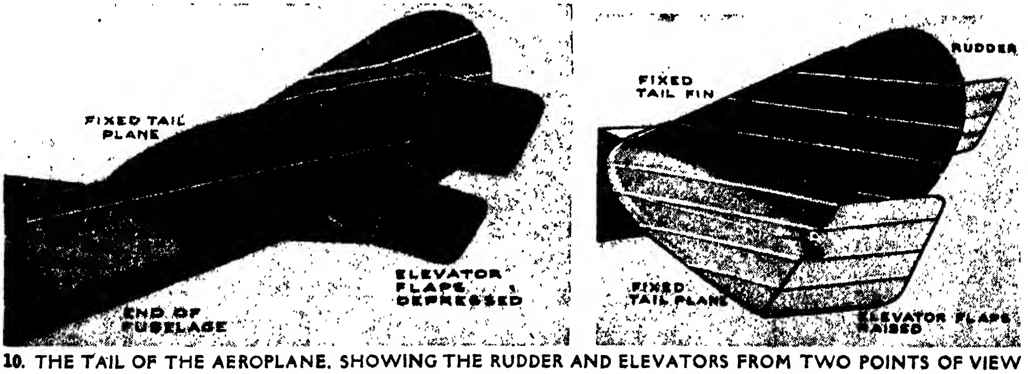
8. THE PILOT DESCENDS—HOW THE ELEVATOR FLAPS ARE PULLED DOWN

This picture and the next show the rise and fall movement. The wires from the control-lever run to the elevators at the tail of the aeroplane, and they act like the rudder, but up and down instead of from side to side. By pushing forward his control-lever the pilot pulls down the flaps, as we see here, thus giving increased lift to the horizontal part of the tail fin, which rises. As the tail rises, the nose points downward, the power of air-suction is lifted from the tops of the planes, and the machine sinks.



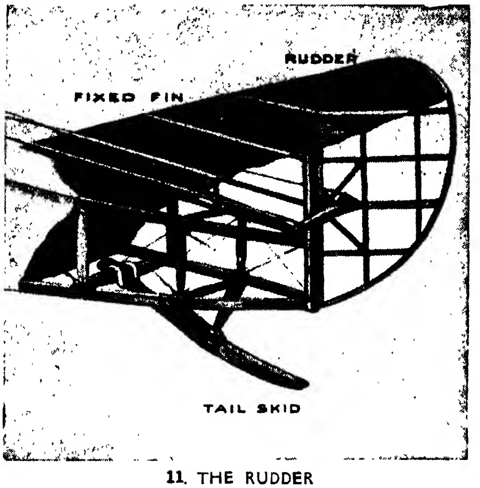
9. THE PILOT ASCENDS—HOW THE ELEVATOR FLAPS ARE RAISED

To rise higher the pilot pulls the control-lever towards him, and the elevator flaps rise upward. This reduces the lifting power of the tail, which sinks down, so that the nose of the aeroplane is highest in the sky. In this position the angle of the wings is, of course, increased, giving them extra lifting power, so that the aeroplane rises.

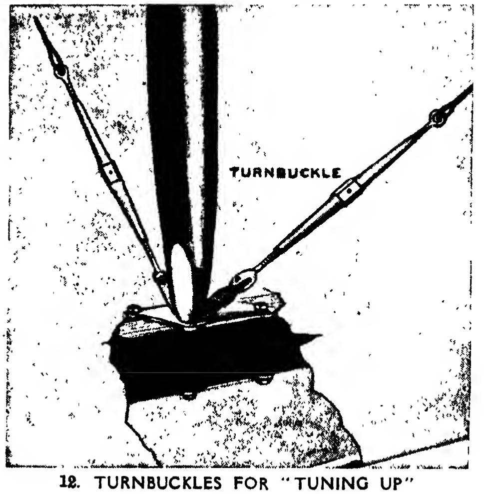


10. THE TAIL OF THE AEROPLANE, SHOWING THE RUDDER AND ELEVATORS FROM TWO POINTS OF VIEW

These two pictures show other views of the tail of the aeroplane, with the rudder, the tail fins, and the elevators at various angles. It is, of course, vital that all these parts should work properly and instantly, and they are easily controlled by feet and hand by the pilot, as we have seen in the preceding diagrams.



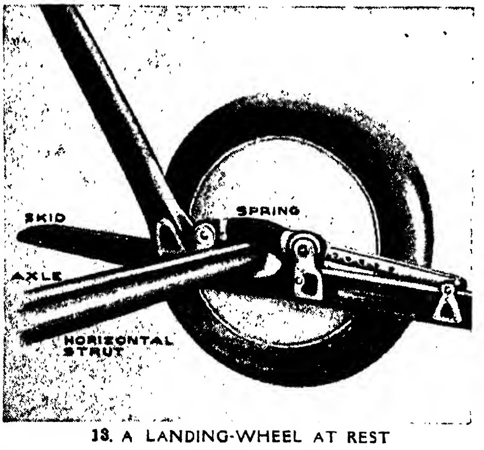
11. THE RUDDER



12. TURNBUCKLES FOR "TUNING UP"

We should note in the last pictures how the tail-fins, the rudder, and the elevators are made. This picture gives a closer view of the rudder with the cover off. The rudder is the piece on the right, and it is worked by wires operated from the pilot's seat. It swings on the steel stern-post at the end of the fuselage, where the upper and lower pairs of longerons meet. Below, attached to the lower longerons by steel springs, is a protecting skid, upon which the tail is safely supported when the aeroplane comes down.

An aeroplane is like a man—it must be fit if it is to do its best. All its parts must respond instantly to the touch of the pilot, and the "tuning up," as the men call it, is exceedingly important. Jolting over uneven ground and the stress and strain of flight may loosen important wires, which must be tested and tightened before every flight. Each wire, therefore, is provided with what is called a turnbuckle, as shown here. This fragment shows a strut resting on a spar of the lower wing and supporting the upper wing.

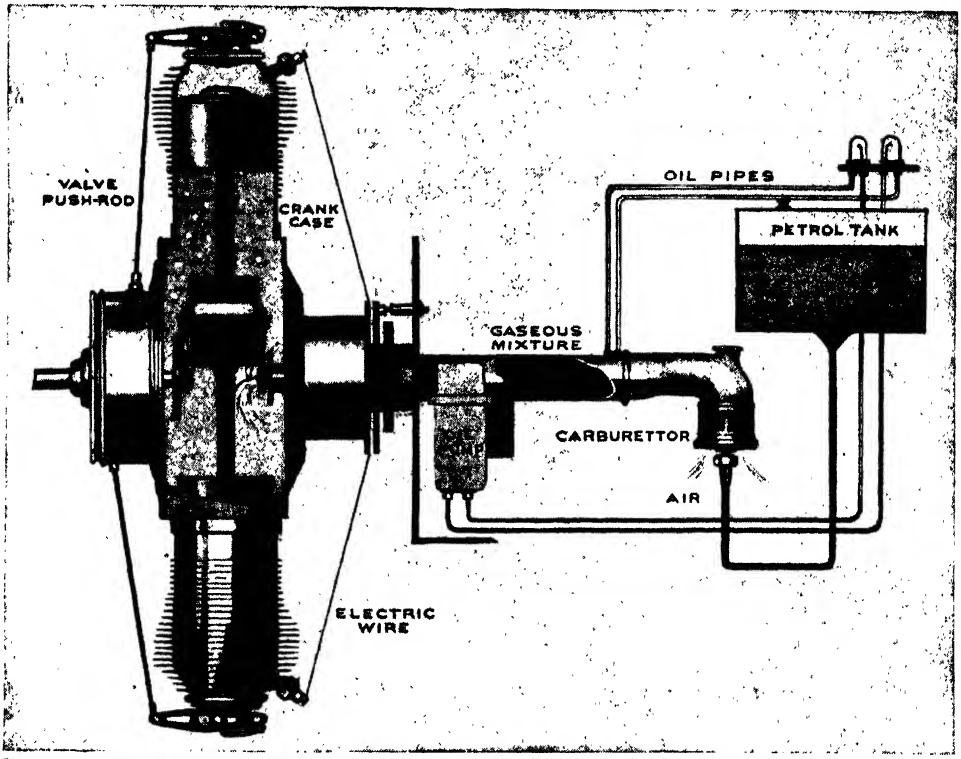


13. A LANDING-WHEEL AT REST

14. A LANDING-WHEEL IN ACTION

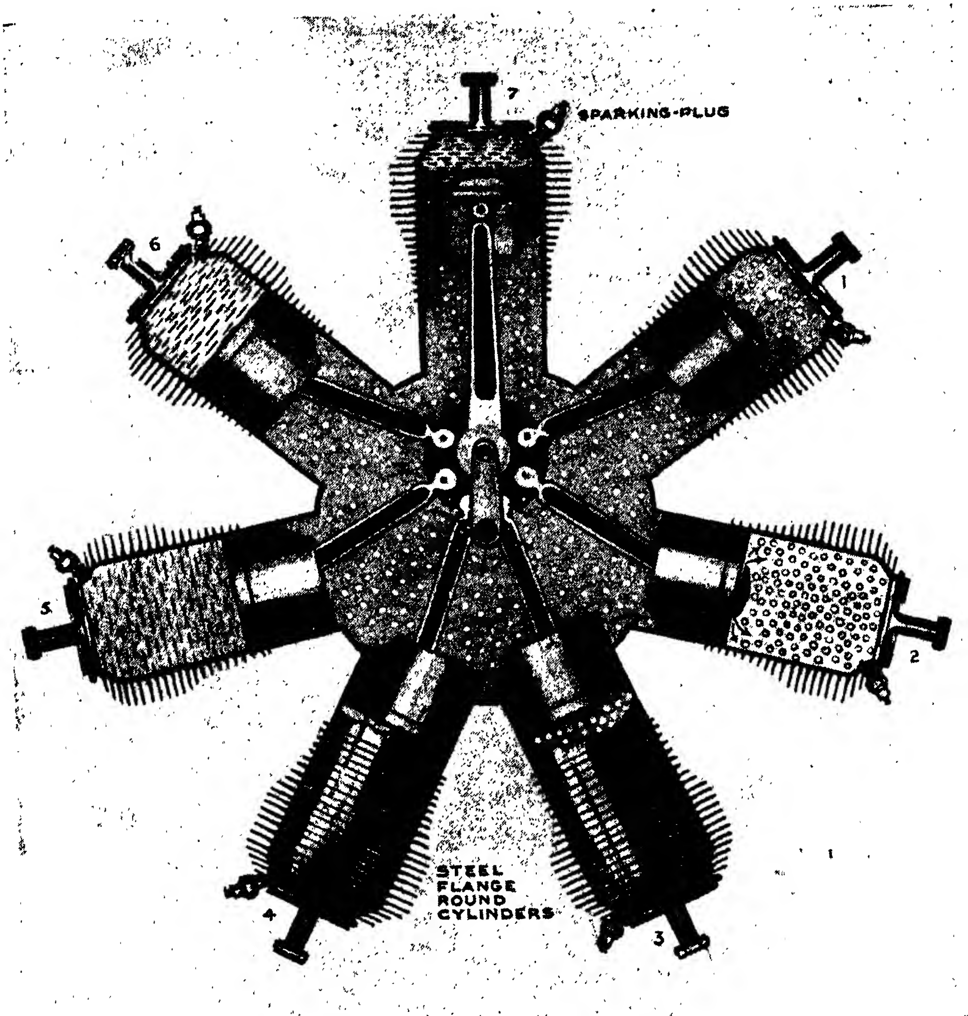
These two pictures show the two positions of the landing-wheels of the aeroplane. The landing-gear is fixed to the fuselage by the upward struts fastened to the horizontal skids by steel clips. The upper bar of the two bars that touch each other is the axle of the wheel; the lower bar is the horizontal strut of the chassis, or

framework. The first of these pictures shows the landing-wheel in its normal position in flight, the second shows it on the ground. When the aeroplane is in flight its weight is resting on the air, and only the weight of the wheels is on the axle, but when the aeroplane comes down the wheels rest on the ground and the weight of the machine must be upheld. These pictures show how ingeniously this is arranged. A spring is fixed to the horizontal skid, and on reaching the ground the aeroplane throws its whole weight upon this spring. In flight the spring rests over the axle of the wheel, but in standing it hangs heavily upon the axle. In your body the cartilage between the joints, especially between the vertebræ of the backbone, takes any shock of violence, and so protects the bone, and it is so with an aeroplane. As the wheels touch the ground the spring stretches, and throws the whole weight of the aeroplane on to the axle, which is able to bear it.



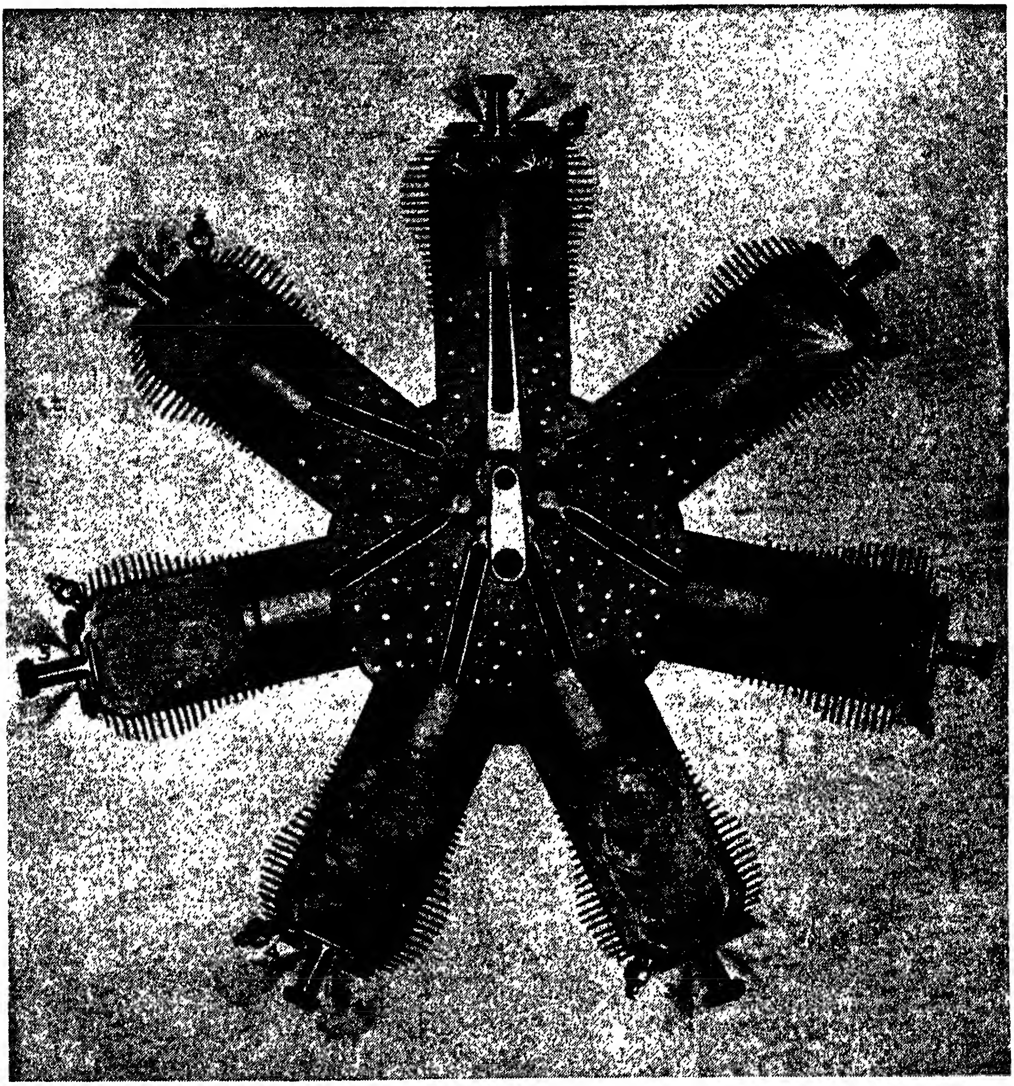
15. THE ENGINE AND THE PETROL TANK—A SIDE VIEW OF THE VITAL PARTS OF THE AEROPLANE

This is a side view of the wonderful Gnome engine of the aeroplane, and of its petrol-tank. The engine is of the internal-combustion type—that is to say, it works by explosions within itself. But it differs from the internal-combustion engines of motor-cars in a very wonderful way. The whole of the engine on the left of the thin wires seen in this picture goes round with the propeller. Petrol passes down the pipe running from the bottom of the tank, and sprays a thin jet up in the carburettor. Inside the carburettor petrol is *broken up* into gas, and mixes with air, entering the carburettor through openings at the side. This mixture of gas and air flows through the hollow centre of the engine-shaft, and reaches the crank-chamber, from which place it feeds the seven cylinders of the engine. Only two of these cylinders are shown here with their pistons and piston-cranks, attached to a central drum. The pistons drive this drum round in a circle, and with it turns the central shaft to which the propeller is attached. The pairs of thin pipes, partly hidden by the petrol-tank, carry oil for lubricating purposes, a pump forcing the oil along.



16. HOW THE GNOME ENGINE WORKS—THE EXPLOSIVE MIXTURE RUSHING INTO THE CYLINDERS AND ITS COMPRESSION BY THE PISTONS

This is the front view of the Gnome engine, showing what happens in each of the seven cylinders. Imagine that this picture represents one revolution of the engine, and the positions of the seven pistons at the same moment. The gaseous mixture that we see, that passes from the carburettor through the hollow centre of the engine-shaft, as shown in the last picture, fills the great crank-chamber in the centre of the engine, the small arrows showing its entry into the crank-chamber and thence to the cylinders. Through each piston is a narrow passage controlled by a valve, so that, as the piston descends, the mixture can pass through. Let us begin at the first top cylinder on the right of this picture (1). We see the mixture passing into the cylinder; the next cylinder below (2) is nearly full, and the next (3) is quite full, the piston being as far out as it can get. The next cylinder (4) shows the piston beginning its return journey, and as it flies back into the cylinder we see it compressing the mixture until in the top cylinder of all (7) the mixture is as tight as it can be. Now it is ready for an electric spark to explode it and force the piston back again.

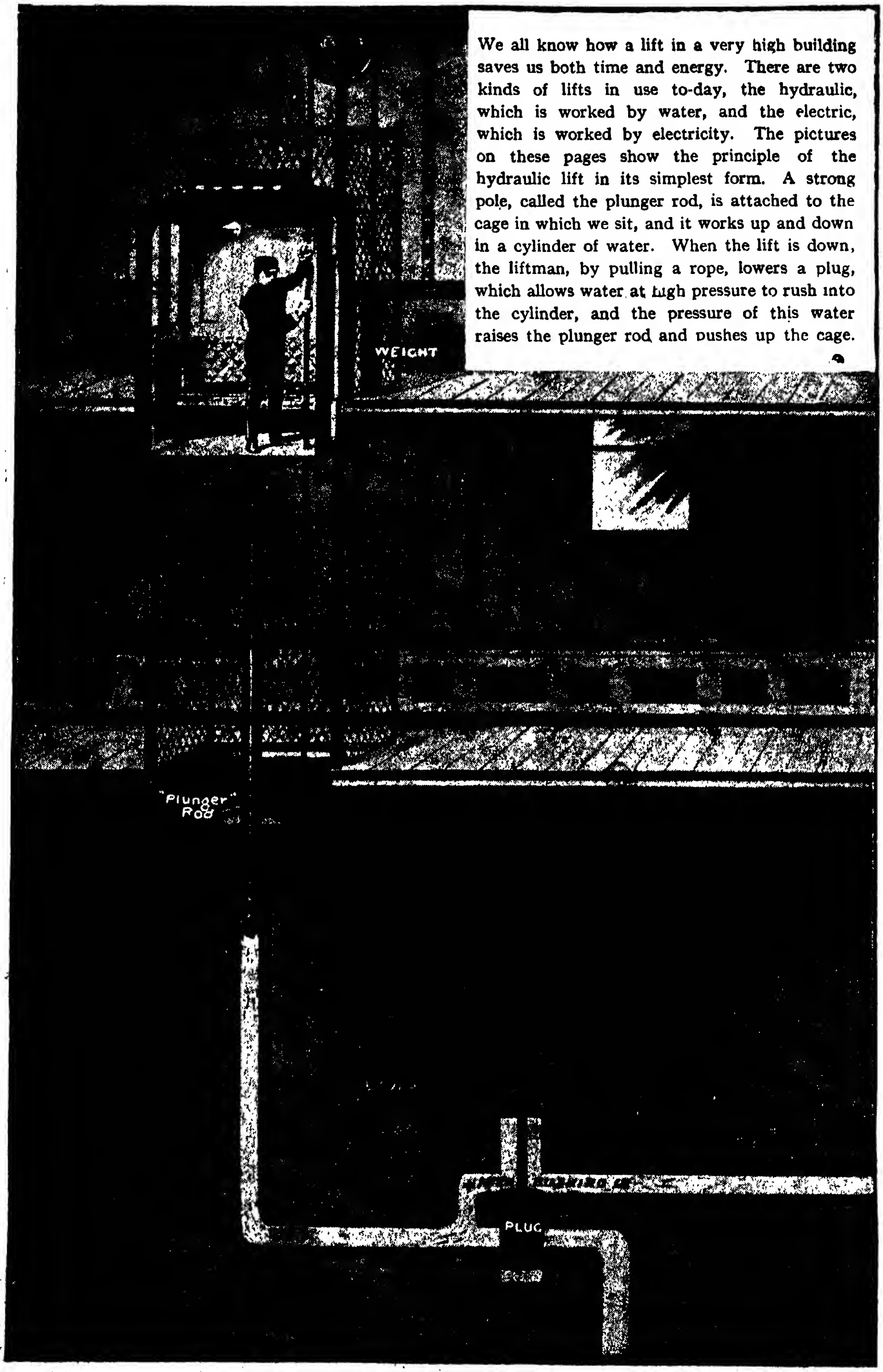


17. THE REVOLVING ENGINE AND THE EXPLOSION THAT DRIVES IT—THE GASEOUS MIXTURE FIRING IN THE CYLINDERS, REVOLVING THE WHOLE ENGINE AND EXPELLING THE FUMES

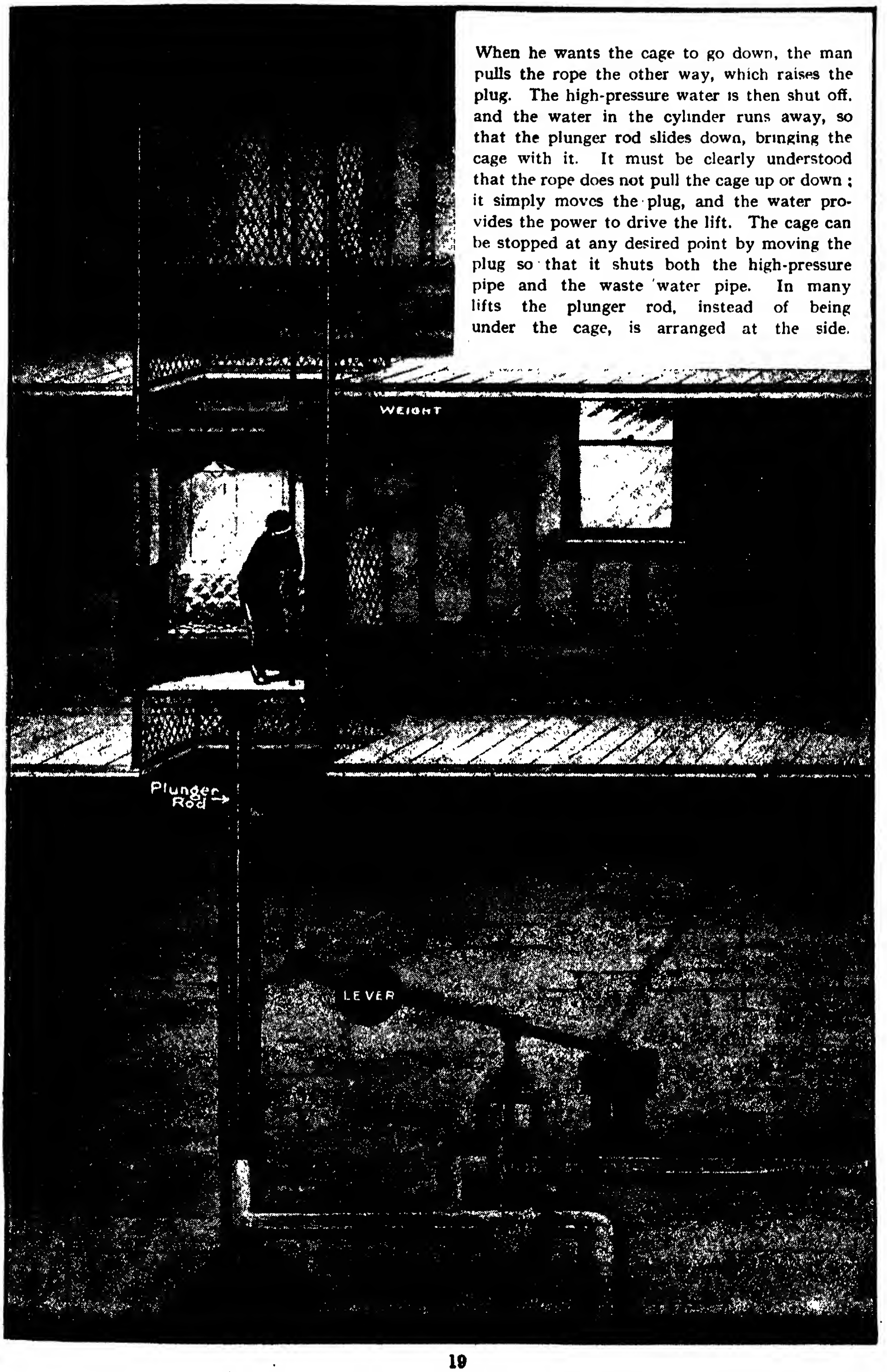
The explosion of the compressed mixture in the cylinder is, of course, the power on which the aeroplane depends. The explosion drives the piston back, the piston drives the central drum round, the central drum carries with it the shaft on which the propeller is fixed, and the propeller screws its way through the air. In the top cylinder on the right of this picture (1) the explosion is just taking place, and as we go round from right to left we see the piston flying back until it is withdrawn to its fullest extent (3). It then flies back to the top of the cylinder, pushing the waste products of the explosion out through the valves, as we see here. There is thus one explosion for every two revolutions of the engine; in the first revolution the piston flies down the cylinder while the gas flies in; it then returns to the top of the cylinder, compressing the gas as it goes. In the second revolution the piston is driven down the cylinder again by the force of the explosion, and drives out the exhaust on its return to the top. So the processes go on, and if they fail the aeroplane comes down. The lower black circle on the white crank is the position of the propeller-shaft.

HOW A LIFT GOES UP AND DOWN

We all know how a lift in a very high building saves us both time and energy. There are two kinds of lifts in use to-day, the hydraulic, which is worked by water, and the electric, which is worked by electricity. The pictures on these pages show the principle of the hydraulic lift in its simplest form. A strong pole, called the plunger rod, is attached to the cage in which we sit, and it works up and down in a cylinder of water. When the lift is down, the liftman, by pulling a rope, lowers a plug, which allows water at high pressure to rush into the cylinder, and the pressure of this water raises the plunger rod and pushes up the cage.



WHAT A PIPE OF WATER CAN DO



When he wants the cage to go down, the man pulls the rope the other way, which raises the plug. The high-pressure water is then shut off, and the water in the cylinder runs away, so that the plunger rod slides down, bringing the cage with it. It must be clearly understood that the rope does not pull the cage up or down; it simply moves the plug, and the water provides the power to drive the lift. The cage can be stopped at any desired point by moving the plug so that it shuts both the high-pressure pipe and the waste water pipe. In many lifts the plunger rod, instead of being under the cage, is arranged at the side.

THE WONDERFUL ROAD THAT A MAN CAN OPEN

The roadway that opens in two at the Tower is one of the marvellous things to be seen in London every day. This picture shows what happens. The Tower Bridge is called a bascule bridge, "bascule" meaning "balancing." The great roadway opens for ships to pass along the Thames, so that the road is actually split in the middle. Each half rests on a pivot, and is balanced by an enormous weight at the tower end. When the bridge is to be opened, a man pulls a lever, which drives water at great pressure through a pipe, and so turns a series of cogwheels. The wheels move a number of curved frameworks with cogs, and the two halves of the road, each weighing 730 tons, turn slowly on their pivots.

WHY THINGS ARE DONE

WHY A GENTLEMAN WALKS NEAREST THE ROAD

When escorting a lady, a gentleman always walks on the side of the pavement which is nearest the road. The reason for this is not so apparent nowadays, when roads are kept clean, as it was in earlier times. A hundred years and more ago the streets were very

muddy, especially in wet weather, and no systematic attempt was made to keep them clean, with the result that the horses and vehicles as they passed splashed up the mud upon passers-by, often spoiling their clothes. This was especially the case in the narrow streets of London and other old cities, where there was no room to get out of the way of the terrible splashing. Chivalry therefore led men, when they were escorting ladies, to keep on the outside, nearest the carts and horses, so that they might receive the splashes and protect their lady friends.

WHY SCOTLAND'S EMBLEM IS A THISTLE

The earliest reference to the thistle as the national emblem of Scotland is found in a document of the reign of James III., dated in the latter half of the fifteenth century. It is generally supposed to have been adopted as a fitting illustration of the royal motto, "In Defence," the thistle being so well provided with sharp points and prickles for its own defence against possible enemies. An old story, however, handed down for centuries, throws back the origin of the thistle

as a national emblem to much older times. It is said that in the days when the Danes used to make foraging expeditions upon the Scottish coast they one day prepared a night attack, and under cover of the darkness were approaching the Scottish camp bare-footed and silent, when suddenly a Dane stepped upon a thistle, and the prickly leaves made him howl with pain, so that an alarm was given to the Scots, and the attack repelled. Ever since that time the thistle has been regarded by the Scots as their national emblem.

WHY A WINDOW HAS AN ARCH

If we look at any house where the upper parts of the flat windows are of brick, we shall notice that the bricks are placed on end, as in the picture, instead of being laid horizontally, as in the ordinary fabric of the wall. Usually, too, the top of the window is arched slightly. The reason for this is that, as the top of the window has to be supported, so that it may not fall in, it needs to be built on the principle of the arch, in which the bricks are so placed and so shaped as to support one another. Even when the top of the window is straight and not curved, the bricks are really put together on the principle of the arch, and, from an architect's

point of view, form an arch. The result of building the window thus is that the pressure on top strengthens the arch, and, by wedging the bricks one against another, prevents them falling.

WHY A TRAMCAR FLOOR HAS GROOVES

We all know that the floors of tramcars and omnibuses and trains on the new electric railways are not flat, like those of ordinary trains, but have battens running the length of the vehicle and close together, though not touching one another. This method of laying the floor is for the comfort and health of the passengers. If the floors were flat, they would

on wet days be very unpleasant, owing to the accumulated mud and water brought in by the passengers' feet. By the device of having battens screwed on to the floor, making a series of gutters between the raised strips of wood, the water is collected in the channels, and the passengers are able to stand and walk upon the battens high up out of the water and mud. Probably many people have been saved from colds with illnesses following because they have not had to sit with their feet in a puddle of water or mud, thanks to the construction of the floor.

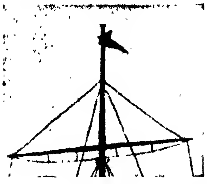
WHY SOME HARBOURS HAVE A TALL FLAG FLYING

At some seaside places that have a harbour, as at Lowestoft, we often see a tall flag-mast

that is visible to boats a considerable distance from the land. On this mast there is sometimes a flag flying, and sometimes a cone. This is really to show the state of the tide and the quantity of water in the harbour, and by looking at the mast the captain or pilot of a ship knows whether or not he can bring his vessel into the harbour. A signal of this kind is particularly necessary where there is a bar—that is, a ridge of sand at the entrance to the harbour. At Lowestoft the flag is flown when the bar has over ten feet of water above it, while at low water the cone is hoisted.

WHY A SHARK'S TAIL IS TIED TO A SHIP'S MAST

THE sailing ships that come into our docks and harbours may sometimes be seen to have what looks like a large piece



of dried leather tied or nailed to the mast or bowsprit. This is really a shark's tail, and has been fastened in position by the ship's crew, who believe that as a result they will have a safe and pleasant voyage. Seamen, especially foreigners, are very superstitious, and they have a particular dread and hatred of sharks; in fact, if they catch a shark, as they sometimes do by means of a piece of pork on the end of a rope, they are very cruel to it. The shark is, of course, a very necessary creature, and acts as a great scavenger of the seas. The tail of a shark fastened to the ship's mast in the manner shown is foolishly supposed to bring good luck to the vessel, though for what reason nobody is able to say.

WHY A FLOWER-POT HAS A HOLE

THERE may be some boys and girls who do not know why a flower-pot always has a hole at the bottom. It is to allow any excess of water that may be poured in at the top or falls upon the mould as rain to pass out at the bottom of the pot, instead of accumulating there and transforming the mould in which the plant is growing into a mass of mud. If there were no hole for the water to pass away by, the plant would soon be killed by the accumulation of stagnant water at the bottom of the pot. It is because of the hole that we must always stand flower-pots in saucers when they are kept indoors; otherwise the water passing out of the pot would run upon the table or window-sill and make a great mess.

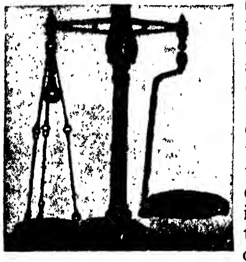
WHY A RAILROAD HAS LITTLE WHITE POSTS

ALL along by the side of our railways outside the big cities there are little posts about 2 feet high, painted white, and bearing the figures, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$. These refer to distances, and mean that one post is a quarter of a mile, or half a mile, or three-quarters from the last mile-post. Every fourth post has a whole number on, such as 1, 2, 3, 17, 100, and this refers to the distance of that particular post from the London terminus. These posts are placed all along the line for the use of engine-drivers, who, by watching them, are able to regulate the speed of their engines.

If we are in a train, and are anxious to know the speed at which we are travelling, it is easy for us to discover it by watching the posts and seeing by our watch how long we take to pass four of the white posts. To do this makes quite an interesting occupation, and if we are alone and have nothing to read, watching the little white posts and discovering at what rate we are travelling helps to pass the time.

WHY A SCALE HAS A WEIGHT AT THE TOP

WE have probably noticed that the large scales used by tradesmen, such as butchers and cheesemongers, have a weight suspended at one end of the crossbeam, just where the chains come down to hold the pans. This weight is not moved on and off the scale in weighing goods as the weights placed on the pan are moved. It remains in position all the time. The suspended weight is really to adjust the balance and keep it true. It is full of small leaden balls, and the top of it can be unscrewed. If by any chance one side of the scale gets heavier or lighter, and the scale becomes untrue, by removing or inserting one or two leaden balls in the suspended weight the balance of the scale can be perfectly restored.



WHY A HORSE WEARS BLINKERS

THE two leather flaps, decorated with brass or steel, which are seen upon a horse's head-harness, and cover his eyes on each side, are called blinkers or blinders. They are placed in this position so that the horse shall be able to see only in front of him, and shall have no view of either side. It used to be thought that if the animal had an uninterrupted view all round from side to side he might be easily startled; but so far from this being the case, there are many who think it far safer to drive a horse without blinkers than with them. They are not used at all for horses that are ridden, nor are they used for horses driven by the military authorities, as in the artillery.

WHY THINGS ARE DONE

WHY AN AXE HAS A CURVED HANDLE

In all modern axes of any size the handle is curved, as shown in the picture. This shaping is not aimless, but is the result of years of experiment, and by its means far more work is obtained from the axe than would be if the handle were straight. By being shaped like a half-strung bow the handle is rendered far stronger and less liable to snap off, and it is also made more elastic, so that it swings more easily, and less strength need be exerted in using the axe. The edge of the blade in all large axes is curved, and there is a reason for this. At the moment that the axe strikes the wood, only one part of the blade touches it, and so all the force of the blow is concentrated on this spot, with the result that the chopping is more effective than it would be.

WHY A FLAG FLIES HALF-MAST HIGH

It is the custom to fly a flag half-mast high when some prominent person dies; and this custom has come down from an old naval and military practice. It has for centuries been the practice in time of war to lower the flag in token of submission to a conquering force, and formerly this was done in order that the victor's flag might be flown above that of the vanquished. Being a token of submission, the lowering of the flag was also regarded as a token of respect to the conqueror, and it is in the sense of respect for the dead that the custom of flying the flag at half-mast when some king or statesman or other prominent person dies has so long been followed.

WHY GOVERNMENT STORES HAVE AN ARROW

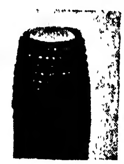
Government stores, and even the clothes of convicts, are always marked with a broad arrow. This practice dates back to the reign of William III., when Henry Sidney, Earl of Romney, was Master-General of the Ordnance Department, that is the Government department that has control of all military stores. His badge, or heraldic device, was a broad arrow, and he conceived the idea of having all the stores that were controlled by his department marked with his badge, the broad arrow, in order to put a stop to the pilfering which was then so general. The practice was continued by his successors, and gradually spread to other Government departments.

WHY A COACHMAN WEARS A COCKADE

Many coachmen wear black cockades in their hats, and although this is often added to their livery by all kinds of people, it should really be worn only by the servants of those who are themselves servants of the reigning monarch—privy councillors, magistrates, officers, civil servants, and so on. The wearing of badges in the hat to show what leader was owned and followed is a very ancient custom. At the time when the Georges were on the British throne, the followers of the Stuarts used to wear the white cockade in their hats, as emblems of the fallen dynasty, and the supporters of the Georges wore a black cockade, which was the badge of the rulers of Hanover, and became the symbol of loyalty to the throne. In course of time it was added by those who held office under the Georges to the livery of their servants.

WHY A TAILOR'S THIMBLE HAS NO TOP

We may have noticed that the thimble used by a tailor or tailoress has no top, the tip of the finger coming right through, instead of being covered as in the case of the ordinary thimble. In using an ordinary thimble the needle is pressed through the material that is being sewn by the top of the thimble, that being the most convenient part to use. But tailors and their assistants have to sew through such thick and hard material that sufficient pressure could not be exerted from the top of the finger. So the side is used, and the thimble needs no top.



WHY WE SHAKE HANDS WHEN WE MEET

Shaking hands when we meet is such a familiar custom that we probably never stop to ask ourselves why our greeting should take this form. Many centuries ago there was a distinct reason why two men should shake hands upon meeting. If they did not know one another, they would each grasp the other's weapon hand, as a precaution against treachery. From this it became the custom for friends to surrender their weapon hands freely to one another.

WHY WHEELS HAVE CURVED SPOKES

In watching machinery we may have wondered why, in many cases, the spokes of the wheels are curved. This adds greatly to the ornamental appearance of the machinery, but it is not for appearance' sake that the spokes are shaped in this way. When wheels are cast the metal always contracts as it cools, and the wheels are liable to crack; but it has been found that those wheels that have curved spokes crack far less often than those whose spokes are straight, and so, for this reason, wheels are often cast with curved spokes. In such cases, the curved spokes give the metal greater play to allow for the contracting that takes place after the metal cools.

WHY GLUE HAS A CRINKLED SURFACE

All boys use glue, and they must notice that most of the glue, when they buy it in pieces at shops, has a crinkled appearance, with something of a pattern on one side at least. This pattern occurs not by design, but because it arises in the process of manufacture. The glue is made from the remains of animals, collected at slaughter-houses, which are boiled down. After the boiling has gone on for a long time, a jelly-like substance is formed, and this, after being partly dried, is stretched out upon netting and left to get solid. The marks on the glue are the impressions made by the netting when the glue was more or less soft.

WHY A PLANE HAS A BUTTON

The larger and better kinds of planes used by carpenters often have a small wooden button, or dome, on top near the front, as can be seen on the plane shown in this picture. There is a very good reason for this button being where it is. In order to loosen the blade of the plane, that it may be taken out for sharpening, the carpenter has to tap the front of the plane with his hammer, and as this frequent tapping would spoil the appearance of the tool, the button is put on in exactly the right place to receive the taps of the hammer, and thus save the woodwork of the plane. The smaller and cheaper kinds of planes do not usually have the wooden button, the woodwork of them generally being plain and not easily spoiled.

WHY SAILORS HAVE BAGGY TROUSERS

Anyone who has seen sailors walking about cannot have helped noticing that their trousers are very baggy—that is, they are very wide, especially at the bottom. This is so much a part of a sailor's uniform now that even when small boys are dressed in sailor clothes their trousers are also made very wide at the bottom. If they were like ordinary trousers they would appear very curious and anything but sailors. The reason for the great size of the legs of the trousers that sailors wear is this. The men have to do so much in and with water, scrubbing and mopping the decks of their ships and so on, that they have to turn their trousers up to the knees to prevent them getting soaked, and if they were like ordinary trousers this would be impossible. So they are made very baggy so that their wearers may be able to turn them up and let them down again without much trouble.

WHY A SIGNAL-POST HAS A CUPBOARD

When travelling by train we may have seen, as we have passed the signal-posts, that at the bottom of many of them was a little box or cupboard, like that shown in the picture. This box has, inside, an electric battery, which is connected with a small signal in the signal-box, and when the signalman pulls the lever and lowers the signal on the post, the little indicator worked by the battery shows him that the signal has gone down and is working properly. These electric indicators are generally used for signal-posts that cannot be seen from the signal-box—those, for instance, that are hidden by a bend in the line, or by buildings. The lid is made slanting, so that the rain, as it falls, may run off at once on to the ground,

WHY A NAVAL OFFICER WEARS EPAULETTES

THE word epaulette comes from the French *epaule*, a shoulder, and means a shoulder-piece. The first epaulettes were plates of metal placed upon a warrior's shoulders in the days when armour was largely worn, and their purpose was to protect the wearer from sword-cuts.

When the use of these metal plates went out of fashion, shoulder ornaments and tassels made of silk and other materials were introduced in France to mark the rank of their wearers, and the custom extended to this and other countries. The epaulette gradually came to assume its present form. It was at one time worn by all soldiers and officers of the Army, as well as by officers in the Navy, but when military uniforms were somewhat simplified, about the middle of the nineteenth century, the epaulette was abolished from them. It has, however, been continued as an ornament for the plainer naval uniforms.

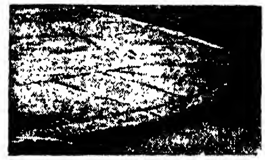
WHY A LAMP HAS A GLASS

THE ordinary paraffin lamps used for lighting purposes always have a glass chimney fixed in the burner. This is an absolute necessity, for without it the flame would not burn properly or steadily, and we should get practically no light, but a cloud of offensive smoke. The flame of the burning paraffin, being so light in weight, is liable to be puffed about by every movement of the air. It needs a steady upward flow of air all round to keep it burning steadily in an upright position, and to supply the oxygen needed for the flame. This regular current of air in an upright position is obtained by means of a glass chimney resting in the burner.

The air passes upward through the perforated or latticework part of the burner into the chimney, where, the flame heating it, it passes up and out at the top, while fresh, cool air is constantly coming in from below.

WHY A PAVEMENT HAS A KERB

IN our cities and towns, where the pathways are paved with flagstones, there is always a kerb running right along the edge of the pavement. This is made of hard granite, whereas the flagstones are of sandstone or limestone, or some similar material made artificially. This is all right for the wear and tear of ordinary foot-passengers, but it is too soft to stand the weight and shock of heavy vehicles, and so a border, or kerb, of the hardest granite is placed at the edge of the pavement. Then when carts and other vehicles draw up by the footpath, and their wheels rub against the edge, this, being of granite is not broken and chipped, but resists the friction of the wheels. Thus the kerb is not simply to give an ornamental and finished appearance to the pavement, as some people suppose, but is really built as a protection to the fabric of which the pavement is made.



WHY A LACED BOOT HAS A TONGUE

THERE are some people who wear laced boots, and do them up regularly every day, placing the tongue in position, who do not know why the boot has a tongue. In the case of button boots, the flap with the buttons comes right across the instep, and in front of the leg, and completely encloses the foot. But in a laced boot the two sides when laced together do not quite meet all the way up, and were there no tongue underneath where the two sides come together the rain would, in wet weather, go through the opening and soak the foot. The tongue is therefore put in laced boots as a protection to the foot, and by closing the opening where the two sides meet it keeps the rain out, thus serving a useful purpose.

WHY SOME SHOPS HAVE THE ROYAL ARMS

WE often notice the Royal Arms set up over the top of a shop-front in London and other cities. This means that the shopkeeper at some time or other has supplied goods to the Royal Family. Only those tradesmen who are thus favoured by members of the Royal Family are permitted to use the Royal Arms. The practice is, of course, now followed as an advertisement, to show the standing of the shopkeeper; but, like the wearing of the cockade, it is really a relic of the old times when tradesmen who supplied goods to a prince or nobleman were expected to wear their patron's livery and to display his arms or badge.

WHY A SHIP HAS FIGURES ON THE BOWS

The reason why vessels have a series of numbers expressed in Roman figures painted on their bows may not be known to all of us. The numbers always run upwards—that is, the highest number is at the top—and the series starts from the keel of the vessel, although, of course, we cannot see these lower numbers unless the vessel is in dry dock. The figures are placed a foot apart, and show at a glance how much of the ship happens to be below the water. In the picture fourteen feet of the boat are under water.

WHY PAILS OF SAND HANG IN SOME BUILDINGS

It is the usual thing to see hanging in large buildings—museums, factories, offices, and so on—rows of pails containing a liquid, which can be used for extinguishing the flames in case of fire. It is quite common nowadays to see also a pail of sand hanging with the others or in a place by itself. This sand is for use in case of fire caused by an accident to the electric wires, bringing about what is known as "a short circuit." If water were used, it would spread the electric current and probably increase the danger, but sand, properly used, very quickly extinguishes the flames.

WHY THE BACK OF A TRAIN HAS STEPS

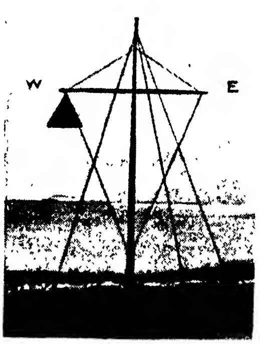
Little plates of iron can often be seen sticking out at the back of railway carriages on our suburban and local railway lines. These are really steps to enable the porters to climb to the top of the train in order that they may walk along the roofs of the carriages and light the lamps. At one time all trains had to be lighted up in this way, but with the advent of electric lighting and the use of gas mantles, with a little burner called a by-pass that is always alight, the lights are turned on from below by a switch, and so the need for the iron steps at the back of the carriage is passing away. They are to be seen, however, on very many trains even in these days.

WHY A SAW HAS A LITTLE NOTCH ON TOP

On most big saws there is a little notch near the end and at the top. This is put there as an aid to the carpenter in his work. Very often, when a thick plank or beam is being sawn, the sawdust or large fragments of wood get wedged into the cut, and make sawing difficult. The carpenter then takes out the saw, turns it round the other way, and, with the notch, clears out the obstruction.

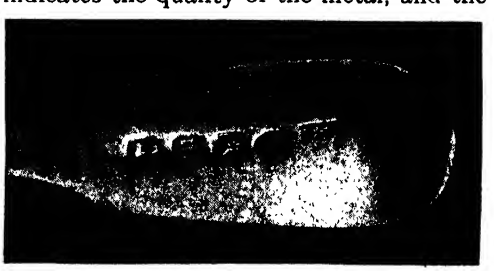
WHY A CONE IS HOISTED AT THE SEASIDE

When we are at the seaside we may often see a cone hanging from a flagstaff. The weather reports in the newspapers, too, often declare that the north or south cone has been hoisted. It is a storm signal, and is hoisted to warn mariners that a storm may be expected. When the point is downward the storm is coming from the south, and when it is uppermost the storm will be from the north. According as the cone is hung on the eastern or western yard-arm of the flagstaff, so the storm may be expected from the north-east or south-east, or from the north-west or south-west. Our picture signals a storm expected from the north-west.



WHY A SILVER FORK HAS MARKS UPON IT

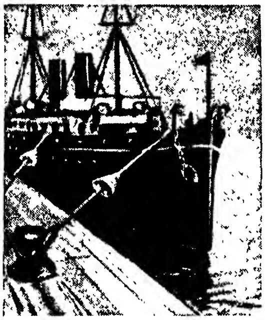
Silver forks and spoons have little marks stamped on them, and the whole series is called the hall-mark, or plate-mark. This is to indicate to the public the genuine value of the metal. The lion in the picture indicates the quality of the metal, and the



m is a sign for the year in which the plate was made and marked. The other marks include the head of the reigning sovereign, a symbol to represent the town where the article was stamped, and the maker's initials.

WHY A MOORING-ROPE HAS A TIN FUNNEL

We have noticed that when a ship is moored alongside a quay there is sometimes, half-way along the rope, a curious funnel-like arrangment, similar to that shown in this picture. The point of the funnel is always toward the ship, and the circumference of the other end is a foot or more. Sometimes instead of a funnel we see a large disc half-way along the rope from the quay. These things are placed on the rope to prevent rats from finding their way into the ship from the land. It is by means of the mooring-rope that these destructive creatures often get on to a ship, but by guarding the rope in this way they are kept back, for they are unable to pass the barrier.



WHY SOME COWS CARRY A PLANK ABOUT

It is no uncommon sight in the country for a cow to be seen walking about the meadows with a long rope round its neck, to the end of which is hanging a large piece of wood, that knocks against its legs and hoofs as it walks. The rope with the wood is hung round the cow's neck in this awkward manner for the purpose of hindering its movements, and preventing it from trying to jump over hedges and gates. Cows seen with this obstacle are in the habit of trying to get through hedges, and with this ungainly necklace they find that their feet get entangled in the wood, and so they are content to remain in the meadow where they have been placed.

WHY A BOOT HAS TWO SIZES MARKED ON IT

When we buy a new pair of boots we notice that there are often two numbers marked on the sole. If we take a six or seven size, we find on looking at the sole that there is not only this number, but also a two, or perhaps a three. The first number is the size of the boot as regards length of foot, and the second number refers to the width. It is called by the shopkeeper the fitting, and, of course, a three is a wider boot than a two. It is important in buying new boots or shoes that we see to it that we get them not only long enough for our foot, but wide enough to be easy or comfortable, for much harm is done by the wearing of boots that are too narrow for the foot.

WHY A RED TRIANGLE STANDS BY THE ROADSIDE

We frequently see by the side of our country roads a red triangle erected on a white post. It is a sign that has only made its appearance during the last few years, but it is now becoming a regular feature of the roads. Its meaning is a warning to motorists. These red triangles are erected where there is some danger to a motor-car, such as an awkward curve in the road, a busy cross-road, or a steep hill. The driver sees the warning sign, and at once slows down until he has passed the place where the danger lies. There are other signs for motorists by our roadsides, but this is the commonest and most useful. County councils and municipal bodies place a speed-limit sign on certain roads. It consists of an upright ring or circle on the top of a post, with a figure below showing in miles the speed per hour that is allowed in the particular district. By the Motor Car Act of 1905 these county and municipal authorities were given the power to limit speed.

WHY A CURVED IRON HANGS IN MANY STATIONS

In many large railway stations where goods trains are loaded we may see hanging from the roof, or from a framework, an iron bar bent into an arch-shape. This is called a load-gauge, and shows the exact height of the lowest arch that trains going from the station may have to pass under anywhere on the line. By running a loaded truck under the load-gauge the railway men are able to know how high it is possible to load a truck without running any risk of the load striking a tunnel roof or a bridge over the line.

WHY A SHOE IS THROWN AT A BRIDE

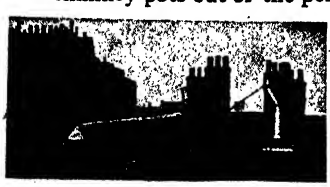
When a lady is married she generally has a shoe thrown after her carriage as she leaves her home for the honeymoon with her husband, but while this is done as an amusing old custom, probably very few people who throw the shoe or tie it to the carriage know what connection the shoe has with the newly-married bride. It is a survival of an old Bible custom which is described in the Book of Ruth, chapter iv. and verse 7, where a shoe is taken off as a token that certain rights of possession are surrendered. Formerly, of course, women were looked upon as the possessions of their father or nearest male relative; and in the East to-day, when a Jewish girl is married, her father presents a shoe to the bridegroom as a token that he yields up his rights in her.

WHY FOOLISH PEOPLE HANG UP HORSESHOES

There are still very many people in Great Britain who are foolish enough to think that if they find a horseshoe and hang it up over their door they will be lucky. This is just a silly superstition that ought to have disappeared altogether. It dates back to the very ancient times when people used to try to discover the future by means of lucky numbers and curious calculations. From the earliest times seven has always been regarded as a very lucky number, because it is used so much in the Bible, and anything that might be found that had seven holes or seven spots was considered to bring good fortune to the finder. A horseshoe usually has seven nail-holes, and so it was supposed to keep away witches from the home or stable. No reader of the Children's Magazine will be so silly as to think a horseshoe brings luck.

WHY A CHIMNEY POT IS BENT

There are two reasons for bending chimney pots out of the perpendicular. When the pot is bent slightly, as in the right of the picture, it is to prevent the wind blowing directly down the chimney, and thus driving the smoke with force into the room. Some chimneys are particularly liable to cause this inconvenience. When, however, we see a chimney bent and carried a considerable distance away as on the left of the photograph, this is to prevent the smoke annoying the occupiers of a building whose windows are immediately over the opening of the chimney pot.

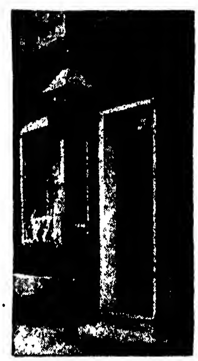


WHY A RULER HAS A BEVELLED EDGE

All flat rulers have an edge bevelled, and the reason for this is to prevent the ink, when a line is being ruled with a pen, from running on to the paper and blotting it. By bevelling the edge, and placing the rule so that the sharp edge of the bevel hangs over the paper that is being ruled, the ink of the pen rubs only on this edge, and is thus kept high up off the paper, and prevented from causing a blot.

WHY A DOCTOR HAS A RED LAMP

Outside nearly every surgery and doctor's house there is a red lamp which has become a kind of trade mark, so that if we are looking for a doctor at night we can usually see his lamp at a distance. We may wonder why it has become the custom for a doctor to use a red lamp rather than a green or blue lamp, or, in fact, one of any other colour. The practice dates back to the old days of the barber-surgeons, when the great remedy for every complaint was bleeding, and the red lamp was chosen as a trade sign because the colour was suggestive of the principal occupation of the barber-surgeons.

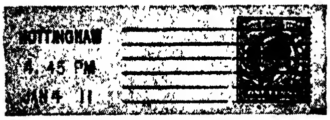


WHY A BISHOP HAS A CROOK

When a bishop is performing any great ceremony, or doing any official act, he usually holds or has carried before him an elaborate crook, beautifully wrought, of silver or gold. This may seem a strange thing for a Church dignitary to have, but it is, of course, an emblem of his office, and is meant to represent that he is a spiritual shepherd. Shepherds in the East and in Scotland carry crooks.

WHY SOME STAMPS HAVE A STRAIGHT POSTMARK

We often receive letters which have a postmark like that shown in the picture, consisting of straight lines with the name of a town. This kind of postmark is always very clear and well defined, and we may wonder why some letters are marked in this neat way, while others have the older and more clumsy form of mark to cancel the stamp.



The mark consisting of straight lines is really stamped mechanically by electricity, and this accounts for its clean and neat appearance. Only those post-offices which are lighted by electricity, and thus have a supply for practical use, are able to use the electric cancellers. The smaller offices use the old-fashioned method of cancelling by hand. With the electric marker as many as five hundred stamps can be cancelled by one operator in a single minute.

WHY A GARDEN WALL HAS A BUTTRESS

When our gardens are divided by brick walls, and the wall is of any length, there are usually several buttresses built out as shown in this picture. These are, of course, to act as stays, and give strength and stability to the wall. The buttresses are always built on that side of the wall which is against the property whose landlord owns the wall and is responsible for keeping it in proper repair. This is true also of the thick posts to which a wooden fence is fastened. If the posts or buttresses are in our garden, and the fence or wall on the other side of the supports, then we own the wall, and must look after it; whereas if the wall or fence faces our garden, and the supports are on the other side, the next-door landlord is responsible for the upkeep of it.

WHY CORRUGATED IRON IS NAILED AT THE TOP

Corrugated iron is now used very extensively for the roofing of sheds and fowl-houses, and also of small churches and halls. If we have watched the workmen fastening the iron in position, we may have noticed that the nails are not put through the gutters of the iron, but through the rising part. The reason for this is that, if the holes for the nails were punched in the gutters, the rain, accumulating as it does in the bottoms of these gutters, would gradually eat away the holes and get through the roof, whereas by putting the nails through the arch-like ridges of the iron the rain does not have a chance of getting through the roof, for it runs down these ridges and off the roof as soon as it falls.

WHY A HOOP IS CARRIED ON PAILS OF WATER

On farms and at places where navvies are working, in fact, wherever much water has to be carried from one place to another, it is no uncommon thing to see a man carrying two pails of water, one in each hand, with a hoop round his body resting on the two pails, as in the picture. The hoop placed in this position enables the man to carry the pails much more steadily and with less effort, and as a result less water is splashed out of the pails. This is specially the case when rough and uneven ground has to be crossed. Any boy can prove the value of the hoop by carrying two pails full of water in the manner described, and then dispensing with the hoop, carrying the pails without the assistance of it.

WHY A MAN TAPS AN ENGINE'S WHEELS

When we have been waiting at some great railway terminus or some large junction on a main line, we have no doubt seen and heard men tapping the wheels of the engine and railway carriages, just before the train begins or continues its journey. The men who do the tapping are called axle-tappers, and they strike the wheels and axles of the engine and coaches in order to discover if there is any defect. Should the axle or wheel be cracked or broken, it will give out a cracked sound, but if the wheel is in good condition the sound will be clear and compact.

It is essential that the axles and wheels should be thoroughly examined in this way, as a defect in any single vehicle of the train might lead to the wrecking of the train when it was going at full speed. Instances have actually occurred of serious accidents resulting from a defective wheel on an engine or carriage.

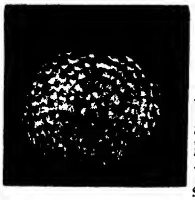
WHY A HOUSE HAS CHIMNEY-POTS

OXYGEN, which is one of the gases that make up the atmosphere, is necessary for the burning of a fire, and if a fire is to burn well there must be a draught of air through it so that there may be a constant supply of fresh oxygen. The rate at which this draught of fresh air travels through the burning embers depends largely upon the height of the flue above the fire, and by adding a chimney-pot to the opening on the roof, the flue is extended and the bright burning of the fire assisted. This explains why, when the fire of a

certain grate will not burn well, the builder overcomes the difficulty by taking away the old chimney-pot and putting a longer one in its place, or by adding a galvanised iron extension to the old one. He thereby makes the chimney-flue higher, so that it will draw very much better.

WHY GOLF BALLS ARE CRINKLED

GOLF balls are always uneven on the surface, but they have not always been made like this. At one time they were made quite smooth. When, however, the smooth



ball was used for play, the blows of the club soon dented the surface, and it was noticed by observant players that the ball always went farther and straighter after it had been dented in this way than when it was smooth. Experiments were made by manufacturers, and gradually the present type of ball was evolved. The explanation of the crinkled ball going farther and more accurately to its mark than a smooth ball is probably that the air, playing upon the unevenness of the surface, gives the ball a twist as it passes along, just as a bullet is given a twist by the screw thread cut inside the rifle-barrel.

WHY A FOUNTAIN HAS A LION'S HEAD

IF we keep our eyes open as we go about and look at the public drinking fountains, so many of which are found in the streets of our cities and towns, we shall notice that the spouts of most of them are carved into the shape of a lion's head. The reason why the spout takes this form is an interest-

ing piece of history. The practice comes to us, through the Greeks and Romans, from the ancient Egyptians, who adopted the lion's head as the symbol of the annual rising of the river Nile. This rise takes place when the sun is in the constellation Leo, or The Lion, and so the lion was used as the symbol for the life-giving waters of the Nile, and fountains were carved with the shape of a lion's head as they are to-day.

WHY A LAWYER WEARS A WIG AND GOWN

THE practice of the law was, in the Middle Ages, confined to the clergy, who, of course, wore their characteristic dress, consisting of a kind of cassock and hood. When laymen began to act as lawyers they wore a gown very similar to that of the clergy, and as a compromise between the monastic hood and the tonsure, or clean-shaven heads, of the clergy, they wore what was called a coif, a kind of nightcap. This cap was originally of linen, but later was

made of silk; and when the general custom of wearing wigs came in, during the seventeenth century, the coif gave place to the wig in the dress of lawyers. Of course, the gown and wig have both changed in shape from time to time, until they developed into their present form.

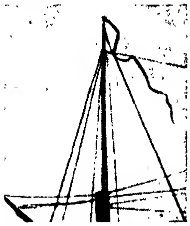
WHY A CHEMIST'S SHOP HAS COLOURED GLOBES

A CHEMIST'S shop usually has several very large globes or bottles of coloured liquid in the window. When the gas or electric light is on at night the light shines through these, and the chemist's shop is recognised at a considerable distance by its bright colours. These globe-like bottles with their coloured liquids are a relic of the old days when the apothecaries

and alchemists used to have a number of retorts and jars, in which they kept or prepared their mixtures, and which were, no doubt, as much to impress th ir clients as for actual usefulness. The chemist has dismissed the retorts from his shop, but he retains the big jars in the shape of these great glass bottles full of coloured liquids.

WHY A SHIP'S MAST HAS A NARROW FLAG

When we have been by the sea we have probably noticed that many of the British ships carry at their masthead a long, narrow flag flying in the breeze. This flag is called the whip, and reminds us of an interesting period in our naval history when it was doubtful whether we or the Dutch should finally rule the waves. The Dutch Admiral Van Tromp captured some of our fleet, and in his pride fixed a broom to his masthead and sailed into the Thames to let us know that he had swept the seas. The English Admiral Blake retaliated by tying a whip to his mast to let the Dutch know that he would thrash them off the seas. Since that time most British ships have carried the long, thin flag, or whip, fastened to their masts.

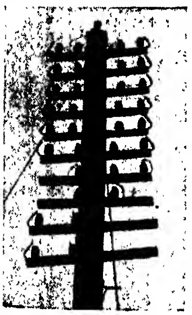


WHY A WALL HAS LARGE AND SMALL BRICKS

If we look at any brick wall, we shall see that it appears to be made up of large and small bricks placed in turn. This is really only an appearance, for the bricks are actually the same size. The explanation of the matter is that, to give strength and stability to the wall, the bricks are laid at right angles to one another. What appears to us as a large brick is a brick laid with its longest side outward. Another brick is laid by its side in exactly the same way, and then, instead of laying the next bricks at each end in the same manner, a brick is laid crosswise with end outward, and so the process goes on, the bricks being laid alternately lengthwise and crosswise, as seen in the picture.

WHY A TELEGRAPH POLE HAS WIRE HOOKS

We sometimes see at the end of the cross-bars on a telegraph pole little wire hooks, or guards, like those shown in the picture. These serve a useful purpose, and not only save trouble and expense to the telegraph authorities, but protect the passer-by from possible danger. They are usually seen on poles that are placed in exposed positions. The wire hooks, or guards, are to catch the telegraph wire and prevent it falling into the road should it become detached owing to an accident to the little earthenware insulator, or cup. Where the line takes a sharp turn, the wires sometimes become detached, with the result that they fall to the ground. Boys have been known to throw stones at the insulators, breaking them and bringing about this result. The wire is, however, in such a case, caught by the guard and held up until it is repaired.

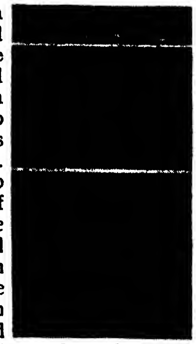


WHY A BRIDE WEARS A VEIL

The veil which a bride wears at her wedding has a very ancient origin. It is derived from the flammeum, or red veil, which Greek and Roman brides wore during the marriage ceremony as a sign of their modesty. The veil covered them completely, and was said to date back to the still more ancient times when men won their wives, not by wooing, but by capture. In those days when a man went wife-hunting he threw a large sheet round the bride of his choice so as to confine her arms, and thus render it easier to carry her rapidly away from her relatives. Even to-day, among some African tribes who win their wives by capture, this method of using a sheet is still followed. Of course, the veil, as worn by European brides, is simply used as an ornament, and has no particular meaning.

WHY A SLEEPER HAS IRON AND WOODEN PINS

The lines on our railways are held in position on the track by being fitted into shaped metal brackets, called chairs, which in their turn are fastened down securely to the wooden sleepers. If we look carefully next time we are at a railway station we shall notice that the pins, or great nails, that fasten the chairs to the sleeper are not both alike. One has a round head and is of iron, while the other is flat on top and is of wood. The reason for using pins of two different substances has to do with the weather. The officials have to allow for extremes of temperature. When the weather is hot the wood shrinks and the iron expands, but when the weather is cold the iron shrinks and the wood expands, so that no matter what the temperature may be the chair is held firmly to the sleeper by one of the pins.



WHY A WEDDING RING IS WORN

The custom of wearing wedding rings comes to us from the Romans, who probably obtained it from the Greeks. Among the ancients a ring, being endless, was the symbol of a binding contract, and when a man betrothed a maiden he gave her an iron ring as a pledge that he would carry out his contract to marry her. From this custom developed the practice of using a gold ring at the wedding ceremony. The

ring has always been worn on the finger next to the little finger, because in olden times it was supposed that there was a vein in this finger that communicated directly with the heart. It was placed on the left hand because, as this hand is less used than the right, the ring probably runs less chance of being worn or damaged there.

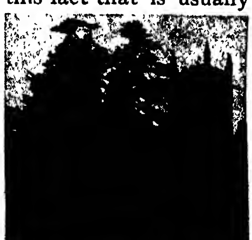
WHY A JEW HAS CASES ON HIS DOORPOSTS

If we have ever visited the house of a Jew, we must have noticed a little case fixed to the right-hand doorpost of every door in the house. This is called a mezuza, which is a Hebrew word meaning doorpost. The case is of metal or wood, and contains a piece of parchment on which are written in Hebrew characters, certain verses from

the Book of Deuteronomy in the old Testament—chapter vi., verses 4 to 9, and chapter xi, verses 13 to 21. The parchment is then rolled up, and on the outside is inscribed the Hebrew word for the Almighty. The parchment is next put into the case, and the case is fixed to the doorpost. There is a small hole covered with glass in the case, and through this can be seen the name of the Almighty. This custom is observed as a literal carrying out of the words "Thou shalt write them—these words—upon the posts of thine house."

WHY CHURCHYARDS HAVE YEW-TREES

Most of us have noticed how common the yew-tree is in country churchyards, and the explanation of this fact that is usually given is that the yew-trees were formerly grown by royal command, so that there should be plenty of tough wood for the making of bows for the famous English archers. Historians, how-



ever, now state that there are no records of commands to plant yews for the making of bows, but that there is a statute of the time of Edward I., commanding that yews be planted in churchyards to protect the churches from the strong winds. The yew is, of course, a tree with very thick foliage, and would serve this purpose admirably. Its dark and gloomy aspect, too, no doubt had much to do with its cultivation in churchyards, its appearance being particularly appropriate to the place where "the rude forefathers of the hamlet sleep." Yews grow to great age, and some of the fine old trees seen in our country churchyards are said to be a thousand years old.

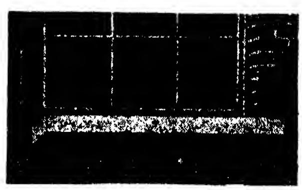
WHY A GENTLEMAN RAISES HIS HAT

When a gentleman meets a lady of his acquaintance in the street, he always raises his hat by way of salute, and this practice is a relic of the old days of chivalry, when knights rode about encased in steel armour to protect them from the sword-cuts and spear-thrusts of enemies. When a knight entered any house as a guest, he removed his helmet to show that he relied upon the protection of his host, and was not afraid of being attacked. For the same reason he un-

covered his head, even out of doors, when talking to a lady whom he knew, and the custom has been continued to the present day; although we do not now wear armour, a gentleman still uncovers in the presence of a lady or when he visits at a house.

WHY A WINDOW-SILL HAS A GROOVE

If we look underneath any window-sill of our house—a place where we do not look in the ordinary way—we shall probably find that there is a smooth, straight groove running from end to end



near the front of the sill. This is really a kind of gutter or drain to carry off the water on a rainy day. Water always collects under a window-sill during and after a fall of rain, and were there no groove at which it could collect until it dropped to the ground, it would run to the side of the sill nearest the house and cause a damp wall. Very few window-sills that have not this gutter channel on the under surface are fitted to houses nowadays.

WHY WE PUT HOLLY IN OUR HOMES

THE custom of decorating the inside of our houses at Christmas with holly, mistletoe, and other evergreens is very ancient, and can be traced back to the old heathen festivals that took place at the same time of the year as we celebrate Christmas. At these festivals the temples used to be decorated with evergreens, and as one of the Scripture lessons usually read on Christmas Eve contained the passage from Isaiah, chapter 60, verse 13, " The glory of Lebanon shall come unto thee, the fir-tree, the pine-tree, and the box together; to beautify the place of My sanctuary," the practice of decorating the churches grew up. This, however, was much opposed at first, owing to the pagan custom, but gradually it got a firm hold, and at last even dwelling-houses were decorated.

WHY CHRISTMAS PRESENTS ARE CALLED BOXES

WE always call a present given at Christmas a Christmas-box, whether it is really a box or not. In olden times alms-boxes were placed in the churches on Christmas Day to receive gifts of money for the benefit of the poor, and these gifts were distributed on the following day, which thus came to be called Boxing Day. Later, the watchmen, apprentices, and others used to go round from house to house collecting for their own benefit, and to receive the money-gifts they had little earthenware boxes. Ever since those times Christmas presents have been known as Christmas-boxes.

WHY THE WAITS PLAY IN THE NIGHT

IT has long been a common custom for the waits and carol-singers to make their visits and give their musical performances in the middle of the night. The practice began with the carol-singers who sang their Christmas songs in the night in imitation of the heavenly choir who appeared to the shepherds at night and sang " Glory to God in the Highest." The waits were originally watchmen, and the word wait means a watchman, coming from a word that stood for " being awake." These watchmen, as they came round, used to sound the hours upon a pipe, and this they had to do to show that they were awake. Attached to the king's court were bands of these waits, or watchmen, who carried various instruments, and later many of the mayors of large cities kept their bands of waits. In course of time these waits became town musicians, and they found Christmas a good time to exercise their profession so as to reap a rich harvest. They followed the custom of the old watchmen and the carol-singers by playing in the night for a week or two before Christmas Day.

WHY WE HAVE PLUM PUDDING

PLUM puddings and mince pies have only been made in their present form during the last two or three hundred years. It was in ancient times the practice for people to give one another at Christmas-time little cakes roughly shaped in the human form, and these represented the infant Jesus and His mother. These became more elaborate as time went on, and developed into a great Christmas pie made up of all kinds of things — chicken, eggs, spices, raisins, currants, sugar, candied peel, and so on. The pies were made in the supposed shape of the manger in which Jesus was laid. The various ingredients, coming, as many did, from the East, were said to represent the gifts of the Wise Men to Jesus. Later the pies were made in the more convenient round shape, and developed into our plum puddings and mince pies.

WHY CHILDREN HAVE CHRISTMAS-TREES

THE Christmas-tree was very little known in England before the coming of Prince Albert, the husband of Queen Victoria, who introduced the custom from Germany. It is supposed to have been derived from a custom of the ancient Egyptians, who used to deck their houses at this period of the year with branches of date-palm, their symbol of life triumphing over death. In Germany, far more than here, the trees are gaily illuminated with lighted candles, a practice that grew out of the custom of keeping a large candle alight at Christmas-time in the churches, to show that Jesus, the Light of the World, had come.

WHY A RAILWAY HAS LITTLE FINGER-POSTS

VERY often by the side of the railway line we can see, when we are travelling, little finger-posts about a foot and a half high. They occur at intervals, and if we are observant we shall have noticed that these are always seen in a hilly country, where

the train is going up or down hill. The purpose of these posts is to tell the engine-driver that he is travelling up or down a gradient, and the slant of the arm of the finger-post shows in what direction the hill rises. The figures 1 in 120 or 1 in 150, or whatever may be on the slanting arm, mean that the land rises 1 foot in every 120 or 150 feet.

WHY A GAS-RING HAS AN AIR-HOLE

WE have probably all noticed that the gas-stove or gas-ring which we use for heating or cooking has a small hole somewhere on the arm through which the gas is conveyed to the burner. This is to allow of air entering and mixing with the gas, so as to increase the heat of the flame. When the flame burns with a yellow light the gas alone is burning, but gas and air together give out a faint bluish flame.

WHY WE GIVE EGGS AT EASTER

WE all like at Easter to give and receive eggs, either made of chocolate or made of cardboard and filled with sweets. The ancient Egyptians and other nations

regarded the egg as a symbol of creation, and when the early Christians were adopting symbols to represent various Christian ideas, they could think of nothing better to represent the idea of resurrection than an egg. From the egg comes the chicken, and the mother hen lives again in the life of her offspring. To make the eggs attractive the shells were coloured to represent some religious idea.

WHY WE HAVE HOT CROSS BUNS

THE custom of eating hot cross buns on Good Friday is a relic of an old custom earlier even than the beginnings of Christianity. Among the ancient Pagans it was the practice to offer in worship to their gods cakes upon which were marked religious symbols. Good Friday often falls at the same time of the year as the Jewish Passover, and as the eating of the Passover cake forms an important part of the Jewish ceremony at that season, the practice of having hot cross buns was adopted by the

early Christians from both Jews and Pagans. From the Pagans they took the idea of marking the cakes or buns with a sacred symbol—the cross; and from the Jews came the idea of eating the hot cross buns at this particular season.

WHY METALS HANG ON TELEGRAPH WIRES

IN many parts of the country little metal plates or discs may be seen hanging on the telegraph wires, where they swing to and fro in the wind, rattling as they strike the wires. These little plates are placed in position to prevent game birds flying against the telegraph wires and getting killed, and they are, of course, seen only in districts where game is preserved for sporting purposes. The pheasants and other birds so often used to fly wildly against the telegraph wires when the beaters roused them and the sound of the firing was heard, that the sportsmen obtained permission from the Government to hang the plates or discs on the wires. The sight and sound of these frighten the birds, and cause them to fly higher or lower, or to turn in their flight, and thus their lives are saved for a time, only to be sacrificed later in a no less cruel manner.

WHY HEATHER IS TIED TO FENCES

A SOMEWHAT similar arrangement to the discs on telegraph wires is to be seen on grouse moors, where the wire fences often have bunches of heather tied upon them at intervals, so that as the grouse fly along they may see the heather and rise above the fence. Of course, many of our smaller birds, those that delight us with

their song, are killed every year by flying against telegraph wires, and it is a disgrace to our modern civilisation that nothing should be done to save these birds, while such elaborate precautions are taken to save the game birds, only that they may be slaughter

WHY A CHIMNEY HAS A BRIM

THE brim, or coping, that tall chimneys have, built round near their top, is not merely for ornament, but is for a very useful purpose, which meets a scientific need. When a strong wind is blowing

against one side of the chimney, a momentary vacuum is caused on the opposite side, and if smoke were coming from the chimney at the time, and there were no coping, it would be pressed down by the air above. It would, of course, be very unpleasant and very unhealthy to have the smoke from great factory chimnews blowing down, so, to prevent this, the coping is put round the chimney near the top, and the smoke is thus kept from going down the side of the chimney to the ground.

WHY SERVANTS WEAR LIVERY

IN the old days, kings and princes used a certain style of dress for the people about their palaces, so that they might be known as royal servants. The great nobles had to provide large numbers of men in time of war for their sovereigns; and these men, called retainers, when they went out to war, were all dressed in the uniform which their lords provided. On the occasion of a festival or display, they would wear their livery for the sake of smartness. Later, the idea of having men in livery was adopted for the army, so that

each regiment could be distinguished by its uniform. But rich men liked the smart and neat appearance of men in livery, and so dressed their servants in something like a uniform. That is the reason why we see servants, as a rule, so dressed today.

WHY BOOK PAGES HAVE SINGLE LETTERS

WE may have noticed that at the bottom of a page every here and there in a book there is a single letter of the alphabet or a figure. This is not a letter or figure that has slipped out of place owing to the carelessness of the printer, but is deliberately placed there for a purpose. If we go

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through a book and count, we shall probably find that the mark occurs at every sixteenth page, though sometimes it is at every thirty-second page, and sometimes every eighth page. The reason for it is this. Books are printed in large sheets, which are afterwards folded up again and again in order to get them to the right size of page for binding; and in order to guide the folders and binders these signs are put on the sheets so that it may be seen quickly in what order they are to be bound up.

WHY A TIN OF FISH HAS A LOOSE PIECE OF TIN

WHEN we open a tin of salmon or lobster we always find a little piece of tin lying on top of the fish. This has not got inside by accident, but is placed in position for a very good reason—to protect the fish from being spoiled as food. When the fish is cooked in the tin, the top of the tin is pierced, so that the steam which has been gener-

ated may escape; then, afterwards, the tin has to be soldered up, and the little piece of tin on top of the fish, just under the hole, prevents the solder getting on to the fish.

WHY A VOLLEY IS FIRED OVER A GRAVE

TODAY the volley fired over a soldier's grave means simply a tribute of respect paid by his fellows to a soldier who has died while in the service, or who has completed good and faithful service. The custom is believed to have sprung from a much older one. People used to believe in the existence of evil spirits, and they thought that if they made a great noise at the side of the grave the dead man's spirit would pass to paradise without interference by evil. Our "passing bell" is a survival of this old superstition. But the belief is not dead. Savages still practise the rite, and the Chinese make the most fearful

noises when they see an eclipse of the sun. Fearing that spirits of evil are about to carry away the sun, they beat drums and cans to frighten away the evil, and they believe the sun's reappearance is due to their efforts.

WHY A SHEPHERD CARRIES A CROOK

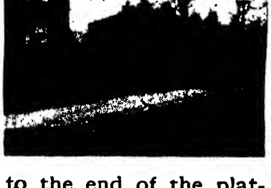
THE crook, or hooked stick, that the shepherd carries in many parts of the country, and which is so familiar in all pictures of pastoral scenes, is not used merely as a walking-stick to aid him as he travels about with his sheep. The hook serves a much more useful purpose in restraining unruly sheep which try to wander away from the main body of the flock. If a sheep tries to break loose from the flock, the hook is placed round its leg, and it is at once a prisoner. The crook is, however, much less used by shepherds in this country than was formerly the case.

WHY A PAWNBROKER'S SIGN HAS BALLS

THE three balls that are so well known as the sign over every pawnbroker's shop were originally the arms of the famous Medici family, that had such power in Florence four centuries ago. The balls represented gilded pills, and they were used by the Medici as an allusion to the profession of medicine, in which some members of the family were skilful, and from which their name was derived. Later they became moneylenders, and though the representative of the Medici was the first to use the sign of the three balls in England, other moneylenders soon copied the sign. It was handed down by the early moneylenders, and then it became generally adopted by pawnbrokers as their sign.

WHY A RAILWAY PLATFORM SLOPES

WE have all noticed that the end of a railway platform never has steps, but is sloped to the level of the railway track. This sloping is in obedience to a Board of Trade rule, and all railway companies are compelled to observe it. The rule was made in order that railway officials might not, in the darkness or fog, stumble when coming suddenly to the end of the platform. The slope, which is called a ramp, enables a man, even when he cannot see where he is going, to know that he is at the end of the platform, and to walk safely down.

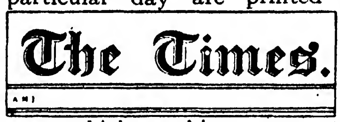


WHY A CHURCH STEEPLE HAS A COCK

AS we go about in the country, we cannot help noticing that most of the old churches that have a steeple with a weather vane on top have a cock at the very top as the most prominent object. The reason why cocks were placed upon church spires, in the first place, was to remind men of Peter's denial of his Lord, and to warn them not to follow his example. Even when this purpose was lost sight of, and its meaning almost forgotten, cocks still continued to be erected on churches to carry out the ancient custom, but now the bird is often omitted.

WHY NEWSPAPER TITLES HAVE WHITE SPOTS

THE white spots that may be seen on some of the letters that form the title of a great newspaper often puzzle people, but the explanation is quite simple. The thousands of copies of the paper for any particular day are printed on several machines, and in case it may be necessary to know upon which machine any particular copy was printed, there is a white dot on a certain letter for each machine. A white dot on the first letter means that the paper was printed on machine Number 1; a white dot on the second letter shows that it was printed on machine Number 2, and so on.

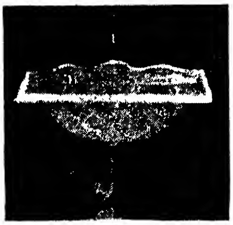


WHY A SAILOR WEARS A COLLAR

THE large square collar that sailors wear, hanging some distance over the shoulders, dates back to the old days when it was the custom for sailors to wear their hair in the form of a pigtail, which was kept well greased. The grease made the back of the coat in a very dirty condition, and so an official order was given that all sailors were to wear a collar that could be detached and washed The collar has continued, although the need for it has long since passed away. The three white lines on the collar are said to refer to three of Nelson's greatest victories. The black scarf which is so often worn by sailors under their collars is a token of mourning for the death of Nelson. After the battle of Trafalgar a general order was issued to the sailors to wear a black scarf, and this order has never been cancelled.

WHY AN OUTLET PIPE IS BENT

If we look at the outlet pipes attached to the washing-basins in our bathroom, and other outlet pipes, we shall find that they are generally bent as in the picture.



There is a very good reason for making them like this. The pipe, of course, carries away the waste water to the drain, and there might be a possibility of bad gases passing up the pipe and escaping into the room. The outlet pipe is therefore bent so that there is always a quantity of water in the lower bend which will act effectively as a valve to close the pipe and so prevent the foul gas escaping into the room.

WHY A FISHING-BOAT'S SAIL HAS LETTERS

When we are at the seaside we probably notice that the sails of the fishing-boats have letters and figures upon them, and we may wonder what these mean. The letters represent the port to which the boat belongs, and the figures mark the number of the boat at that port. Every fishing-smack has to be registered at some port, and the name of the port is usually indicated on the sails of the boat by the first and last letters. Thus, in the picture given here, the letters L T show that the boat belongs to Lowestoft, and 519 is the registered number of this particular boat at Lowestoft.

It will be interesting for us, the next time we are at the seaside, if there are any fishing-boats about, to look out for the letters and figures. Pilot boats usually have only one letter, the first letter of the port's name.

WHY A LADDER HAS A NUMBER

At the yards of most big builders where there are a large number of ladders for use in repairing the outsides of houses, it is usual to have a number painted or branded upon the inside of one of the uprights, as seen in the picture.

This does not mean that the ladder is the thirtieth or fortieth ladder—or whatever the number might happen to be—in the yard, for ladders are not numbered like cabs, but it indicates the number of rungs, or steps, in the ladder. The workmen are thus able to choose a ladder of any length required by simply glancing at the number on it. They know how far a certain number of rungs will reach, and are able to choose their ladder accordingly.

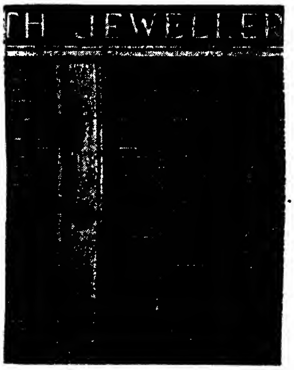
WHY STRAW IS HUNG UNDER A BRIDGE

It is no uncommon thing for a bundle of straw to be seen hanging, as shown in this picture, from the arch of a bridge that spans a river used for navigation.

The meaning of this curious sign is that the bridge must be passed under with care, and that the sailors must be on the look-out that nothing drops upon them from above, for the bridge is being repaired. It is not known exactly when and why straw was used for this purpose, but probably the workmen who first used it as a sign wished to warn the boats passing in the river underneath them. Having no signboard, and some straw being handy, they hung this in the position shown to attract attention to their scaffolding. The custom has continued, and is now recognised all over the country by bargemen and others navigating our rivers and canals.

WHY A JEWELLER'S SHUTTER HAS A GRATING

In the iron door of a jeweller's shop, or in the wooden shutter that covers the doorway of other shops, a small hole or grating may often be seen.



This serves a useful purpose, for it enables the policeman on the beat to peep through when the shop is shut, and see that all is right inside. A light is frequently left burning all night, so that the policeman can see inside the shop quite clearly. More than once a burglary has been discovered and the thieves have been caught, because the policeman, on looking through the peephole in the door, noticed that something was wrong, and, having obtained help, he was able to seize the thieves before they made their escape. The shape of the hole varies in different shops.

WHY A SHIP HAS A CIRCLE AND LINE

We have probably often noticed that ships have painted on the side of their hulls a circle with a horizontal line through it. This is known as the Plimsoll mark, and is named after Mr. Samuel Plimsoll, the member of Parliament who devoted his life to the interests and well-being of our seamen. It was through his efforts in 1876 that the Merchant Shipping Act was passed, by which the Board of Trade was given power to stop any vessel leaving port that was considered unsafe. Ship-owners were compelled to put on their vessels a circle twelve inches in diameter, with a horizontal line eighteen inches long running through it, and no vessel is allowed to be loaded so that the part of the ship above the horizontal line is in salt water. Any breaking of the law involves a fine of not more than a hundred pounds.

WHY SOME WALLS HAVE HOLES

We may often notice small openings between the bricks on the lower part of walls where the earth is higher on one side than on the other. These holes serve a very important purpose; they really protect the wall from crumbling away. Where on one side the earth is higher than on the other the rain-water drains down toward the wall, and if there were no holes through which it might pass it would accumulate, and the bricks would become saturated and gradually crumble away. But, as the water can pass through the holes that are left, no such unfortunate result occurs

WHY STAMPS ARE PUT HERE

We always stick the postage stamp in the top right-hand corner of an envelope, and there is a very good reason why this corner has come to be selected as the place for the stamp. All stamps have to be cancelled with a black mark as they pass through the post-office, and it is important, with the millions of letters that are handled, that the officials who do the cancelling of the stamps should be able to find them easily. The most convenient place is the top right-hand corner, as this is the place the right hand of the official holding the cancelling instrument would naturally strike at. Of course, in big post-offices, the stamps on letters are now cancelled mechanically by electricity, but, as many thousands of letters are still treated by hand, we should always try to help the officials by putting the stamps on our letters in the most convenient place.

WHY TRAINS HAVE CURVED STRIPS ON TOP

If we look at the roof of a railway carriage, we shall notice that on each side there is a narrow piece of wood raised above the roof, and running from one end of the carriage to the other. It touches the angles at each end of the carriage roof, but, in the middle, curves upward toward the centre of the roof. The purpose of this arrangement is to prevent the water in rainy weather from running off the roof upon the heads of passengers as they get in and out of the carriage. The water is, by means of the curved wood, directed to the ends of the roof, where it pours off on to the ground.

WHY A HOP-KILN HAS A MOVABLE TOP

We all know the curious funnel-shaped top which a hop-kiln, or oast-house, has, and usually these tops are made to move round. We may have seen the top suddenly turn while we were looking at it, and perhaps we have wondered why the funnel-like top should move at all. The turning is to prevent the wind blowing down into the kiln, and hindering the vapour from the hops passing away. By turning the top round so that it points in the opposite direction to that from which the wind is blowing, an undesirable draught down the kiln is prevented.

WHY A HUSSAR'S BUSBY HAS A FLAP

We all know the striking coloured cloth flap that hussars wear hanging down on the left side of their hats, or busbies, and we may have wondered what this is for. Of course, at the present time it is nothing more than an ornament distinctive of this particular kind of cavalry, but its origin and meaning are very interesting. The original hussars were Magyar cavalry, who were so expert and efficient in the field that most European sovereigns formed regiments of hussars, and copied, not simply the idea, but the peculiarities of the uniform from the Magyars. One of these peculiarities was a long narrow bag attached to the hat, which the men allowed to hang over their left shoulder to protect them from the sword-cuts of the enemy. The bag was, of course, very cumbersome and inconvenient, and was gradually done away with, although its memory still remains in the coloured flap of the busby.

WHY A TELEGRAPH POLE HAS A ROOF

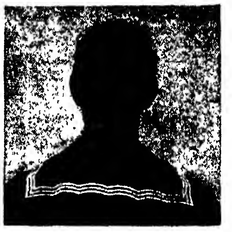
If we look up at the next telegraph pole we pass we shall notice a little roof, shaped like a V upside down, completely covering the top. It is called a pole-roof, and it serves as a protection against rain, which would otherwise collect on the top of the pole, soak into the wood, and in time cause it to split and decay. The little gable roof projects slightly over the pole, so that when the rain strikes against it the water slides down and shoots away clear of the wood.

WHY A BRIDE HAS A CAKE

The elaborate cakes, with massive almond paste and gay decorations of sugar, without which no wedding is now considered complete, first took their present form in the extravagant days of Charles II. But their origin and meaning date far back, before English history began. When the Roman brides of early days were married, they used to eat a simple cake of flour, salt, and water, and hold in their hands three grains of wheat, these things being regarded as symbols of the necessaries of life, which it was hoped the bride and her husband would always have in plenty. From the Romans the custom spread to other nations. The wheat-grains were increased in number, ground into flour, and made into little biscuits, which were divided among the guests. Then other ingredients, such as eggs, currants, and so on, were added to make the cakes palatable, until in Charles II.'s reign the cakes were made very much as they are now. The wedding cake, therefore, is a symbol of the plenty which it is hoped the bride will always enjoy.

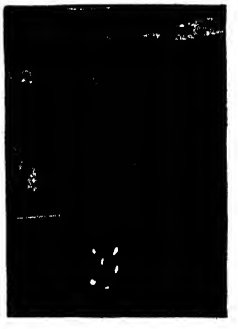
WHY SOME SAILORS' COLLARS HAVE WAVY LINES

We may sometimes have seen what appear to be Jack Tars about the streets, but instead of the usual border of three straight lines round their collars they have three wavy lines. Many people, when they see these men in London or elsewhere, think that they are foreign sailors, but they are really nothing of the kind. They are British man-o'-war's-men, but instead of being regulars they are naval volunteers. In other respects the uniforms of the regulars and the volunteers are almost identical, there being a slight difference in the band of the cap. It may be news to some readers that there are naval volunteers at all, as they are far fewer than the Territorials, or military volunteers, of whom, of course, there are many, and these are often seen in our streets.



WHY A TRAIN HAS BARS ON ITS DOORS

A few years ago it was always possible to put our heads out of the upper part of a railway-carriage door when the window was let down. If the space was barred at all, it was only by a single iron rail, which did not prevent our reaching out. Nowadays, however, on some railway lines the doors are barred with double rails, so that it is quite impossible for even a child to put his head out of the window, so small is the space between the bars themselves, and between the bars and the top and bottom of the door-space. The reason for this barring of the doors is that on some railway lines—such as the Great Eastern, for instance—the width of the carriages has been increased to allow of more passengers being packed into a train. The track has not, of course, been widened, and so the wider trains in passing one another in opposite directions are much nearer together. This means that if people in passing trains leaned out of the windows they would knock their heads and be seriously injured, if not killed, and so the bars are put up to prevent anyone leaning out.



WHY A DRAPER PRESSES A SOVEREIGN ON THE BILL

Usually in a draper's shop, if the customer hands over a sovereign to pay for the goods she has bought, the shopman will press

the sovereign down with his finger on the bill before sending it to the cashier's office. This is to prevent any dispute after the coin has left the counter. When the shopman presses the sovereign, or half-sovereign, as the case may be, a slight impression of the coin is made by the carbon sheet on the duplicate of the bill underneath, and this impression is clear enough to show what the coin is. The customer is thus protected from any fraud or mistake, and the shopman is able to make clear to the customer what coin she handed over if she is in doubt.

WHY THE BOW OF A HAT IS ON THE LEFT SIDE

In the olden times most men had to be ready to fight at a moment's notice, and it was important that no detail of their dress should interfere in

any way with the use of their weapons. For this reason hanging plumes and feathers were always worn on the left side of the hat, so as to leave the right side free for the movements of the sword. When ribands and bands were worn round the hat or cap to pull it tightly to the head, the bow was tied on the left side for exactly the same reason; otherwise the sword might have become entangled in the hanging ends. The band round a man's hat is simply a survival from the days when a loose hood or cloak was tied round the head, and the small flat bow is still continued on the left side.

WHY SOME SAILING BOATS HAVE BOARDS AT THE SIDE

A good many sailing boats at the seaside may be seen to have large boards attached to each side with a chain, holding them up flat

against the side of the vessel. These boards are called lee-boards, and are attached to flat-bottomed sailing boats. When the vessel is about to tack, the boards are let down by the chain from the after part of the vessel, and act as a keel, thus preventing the boat from capsizing. On the other hand, when the vessel is going on a straight course, and the boards are not required for the purpose mentioned, they are drawn up once more by the chain and kept flat against the sides. Of course, ships that have keels are not fitted with lee-boards, as they do not require them.

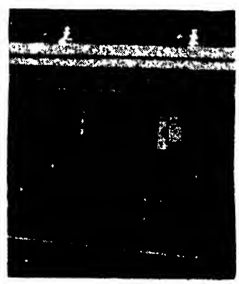
WHY SOME GROYNES HAVE POSTS AT THE END

Most of our seaside places have groynes or breakwaters built out into the sea, and in some cases there is a post at the end of each with some kind of a prominent structure at the top.

These are erected at places where the groyne is completely covered at high water, and where it juts out a considerable distance into the sea. Were there no tell-tale post at the end to give warning of the groyne's existence at high water, boats might collide with the breakwater, and both damage it and be damaged themselves. The post with its prominent framework at the top, which is never covered at the highest tide, shows plainly where the groyne is. The top of the post is usually like a cage, so that the rough seas may wash through it. If it presented a flat surface, the pressure of the waves would be tremendous, and it would soon be washed away in a storm.

WHY A TRAIN HAS PROTECTED VENTILATORS

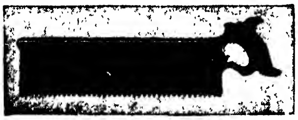
If we look at the roof of a railway carriage, we shall see that the opening for the ventilators is not a mere grating, but is a rather elaborately shaped structure. The reason for this special contrivance is



that, owing to the high speeds at which a train travels, no ordinary ventilator would do. If there were merely an opening in the roof, the air from inside the carriage would not be able to escape, for the rush of wind along the roof of the carriage as the train dashed on its way would act as a covering to the ventilator, keeping the foul air from coming out. The ventilator, therefore, is so arranged that the opening is not immediately in contact with the outside air, and as the vent is protected from the rushing wind by a screen, the foul air from the carriage is able to escape as required without difficulty.

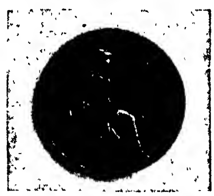
WHY SOME SAWS HAVE STIFF BACKS

WHILE some saws are long and more or less flexible, there are others which are short, and are kept perfectly rigid by a stiff back of brass or steel running down the blade. These short, stiff saws are called tenon saws, and are used where a small section of wood has to be sawn with great accuracy, as in making the tenon, or recess, at the end of a beam, into which the mortise, or projecting section, at the end of another beam is to fit. It is important, in making such cuts, that the saw should not bend in the slightest degree, and the stay of metal down the back insures this. The saw that a butcher uses is very similar.



WHY A DRAPER GIVES A FARTHING CHANGE

AS we know, drapers almost invariably mark up their goods at so much and elevenpence three-farthings—11¾d., 1s. 11¾d., and so on. This curious custom, which is now general all over the country, originated with a small draper who had a business in the Borough, South London. Anxious to gain the custom from his rivals, he thought of the happy idea of taking a farthing off the price of all goods that came to a shilling or an even number of shillings, rightly concluding that the public would consider 1s. 11¾d. a much cheaper price than 2s. It certainly looks much less on a ticket, and the success of this draper soon caused his rivals to follow his custom. The practice of giving a packet of pins in place of the farthing is more recent.



WHY AN UMBRELLA HAS A FERRULE

AN umbrella that has no ferrule at the end looks unfinished and far from graceful, so used are we to seeing these attachments at the ends of umbrellas and walking-sticks. But the purpose of the ferrule was not in the first place to lend finish to the umbrella and to make it look neat. It was really to save the stick from wearing out. When all umbrella-sticks were of wood, it was necessary that there should be a ferrule, for the friction on the end, as it constantly struck the hard pavement, would soon wear it down, and make the umbrella both untidy and short. Now that steel rods are coming into such general use, and umbrellas are so cheap that most people buy new ones when their old ones are worn out, instead of getting the old sticks re-covered, the need for a ferrule is not so great. But they are still added, principally for appearance' sake, being now made part of the metal umbrella-stick.

WHY A LAST IS IN TWO PARTS

WE may have noticed, when visiting the shop of a shoemaker who makes the boots himself, that the lasts, or models upon which he builds up the boots, are in two parts. There is the main part of the last in one piece, with a second somewhat wedge-shaped section in the place of the instep, which can be removed from the other part. Whether the last be of wood or of iron, it is always made in two pieces. The reason for this is that when the boot is finished, the last could never be drawn out in one piece; and so the instep part is pulled out first with a hook that fits into a hole in the last, and then the rest of the last is drawn out in the same way.

WHY NEW BUILDINGS HAVE WOODEN SCREENS

WE sometimes see hanging down the front of a fine new building that is nearing completion a great wooden screen made of planks. This screen is to protect the walls of the building from damage. In modern building operations a very tall staging is built up, and a crane is erected on this for the purpose of hauling the iron girders and blocks of stone into position. This new method of building saves a great deal of time and expense, being much quicker and cheaper than the old-fashioned system of building a great scaffolding, upon which the men could work. When the walls are practically complete, but material has still to be hauled up by the crane, the swinging load on the end of the chain might strike against the wall and greatly damage it. So the large wooden screen is hung down the face of the wall and effectually protects it, should the chain swing against it.

WHY A SCOTSMAN WEARS A SPORRAN

THE curious, ornamental bag covered with fur or hair which a Scotsman wears hanging down in front of his kilt is called a sporran, and its name explains its origin, for sporran is really the Gaelic word for purse or pouch.

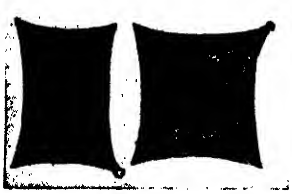
This curious object is now worn principally as an ornament, and is often highly decorated with silver or metal mountings, but originally it was just a simple leathern bag. The Scottish kilt not containing pockets, the Highlander needed some receptacle in which to put any small objects that he wished to carry, and so it came to be the custom for him to have a leathern pouch slung from the belt round his waist. This bag has grown more and more elaborate as the Highland costume has become more generally used as a uniform by wealthy men and soldiers.

WHY PART OF A GAS-LAMP IS SOMETIMES DARKENED

IN certain positions we may see a gas-lamp which is used for lighting a public thoroughfare with one of its sides darkened, so that in that particular direction it can give no light. These lamps, we shall find, if we take notice, are always on or close by a bridge across a railway, and the reason for masking one side of the lamp is to make it quite certain that the light will not be taken by the driver of an engine for a signal-lamp. There are quite a number of such masked lamps to be seen in different parts of London and other large cities.

WHY AN AIR-CUSHION IS IN SECTIONS

WE all know the air cushions and pillows which invalids find so comfortable when they have to lie down during long periods of illness or weakness. These consist of a square or oblong india-rubber bladder covered with some soft material, and are blown up through a nozzle, or mouthpiece, at one corner. But the rubber bladder does not consist of one compartment like an ordinary pillowslip or cushion-cover: it is divided into sections, as shown in the picture. The reason for this is to keep the cushion more or less level. If there were no divisions in the bladder, when it was blown up fully the cushion would be almost round like a balloon and quite useless as a pillow. Sometimes the divisions are simply straight across the cushion, as in the first one shown in the picture, and at other times there is a circle with divisions radiating off. The division into compartments keeps it more or less level.



WHY THE SIDE OF A HOUSE HAS WHITE LINES

WE often see on the side of a tall building adjoining a piece of vacant land a number of white, upright lines, starting with squares or oblongs, at various heights on the wall, but all reaching to the top. These are really the marks that indicate the positions of the fireplaces and chimney-shafts in the building, and they are thus placed on the outside of the wall so that, when another building is put up alongside, the corresponding positions may be followed in building the chimneys and fireplaces. The clear marking of the positions on the wall in this way saves a great deal of trouble, and leaves nothing to uncertainty.

WHY ANTIMACASSARS HANG OVER CHAIR-BACKS

IN many houses we see antimacassars of crochet work or silk hanging over the backs of the chairs, although the practice is not nearly so common as it once was. When antimacassars first came into use, last century, they served a very useful and important purpose. It was formerly the practice for men to use hair-oil, and this was known as Macassar oil, because much of it came from the district of Macassar, in Celebes Island, near Borneo. Upholstered chairs used to suffer from the custom, for when the men placed their heads back on the upholstery the oil on their hair would stain the tapestry or velvet. It therefore became the practice of thrifty housewives to hang wraps over the backs of their more valuable chairs, and, naturally, these were made as ornamental as possible, so that gradually they were extended to all chairs. The name anti-macassar indicated their use.

WHY THERE ARE ALWAYS TWELVE JURYMEN

An ordinary petty jury in a court of law always consists of twelve men, and the custom of having this number, neither more nor less, can be traced back to very ancient times. The ancestors of the Northmen who conquered these islands had a great veneration for the number twelve, and the Christian inhabitants of England also regarded this number with respect, because there were twelve patriarchs, twelve tribes of Israel, and twelve apostles. So when the selection of a number of men to give a verdict in a trial became a part of the practice of the law, it was natural that this number, having such sacred associations, should be decided upon.

WHY BOOTS AND SHOES HAVE HEELS

All our boots and shoes have heels, some of them on ladies' boots being very high indeed. These are to raise the back part of the foot, and throw the weight of the body forward on to the toes. This greatly assists us in walking, for were there no heel to our boot we should drop back with our feet flat on the ground, and a considerable amount of energy would be needed at each step to rise on the toes and go forward. How difficult and tiring it is to walk for any length of time without artificial raised heels to our shoes, we can test by trying to walk round and round the garden for half an hour in heel-less slippers.

WHY A HOODED CART HAS WINDOWS

Whenever we see a hooded cart or van in the streets of London, we shall notice that there are little windows on each side of the hood near where the driver sits. Sometimes these are mere openings without coverings of any sort, and at other times they will have glass or mica window-panes. These are for the use of the driver, who is thus able to look out on each side of him and see if the road is clear should he desire to turn his van to the right or left. A few years ago the vans were not equipped in this way, but by a police regulation all hooded carts plying in the streets of London must now be fitted with windows, so that the driver can see the road on each side, and be saved from causing accidents.

WHY THE END OF AN ANVIL IS TAPERED

We have probably noticed that the anvil upon which the blacksmith beats out the iron that he heats in the furnace consists of a block of iron or steel with a flat surface, called the face, and at one end a projecting piece that tapers to a point like a bird's beak. This is called the beak, or bickern, the second name meaning two horns. The older anvils were made with a beak at each side, and so the name bickern was given because they looked like the two horns of an ox. Now, however, anvils are usually made with only one beak. The beak is the part of the anvil on which pieces of iron are curved, as when a horseshoe is beaten round, the gradually narrowing iron or steel enabling the curved piece that is being formed to be shaped round it.

WHY A LOCOMOTIVE HAS DISCS IN FRONT

On some of our railways the engines have, fixed in front of them, round discs. Some are white and others green, or green with a white border round, and on different engines they are fixed in different places. They do not appear on the locomotives at night, their places being taken by lamps fixed in the same positions. The reason why the discs, and also the lamps, are placed in this way on the engines is that the signalmen and porters may know the destination of a train. When the train is yet some distance from the station or signal-box, it is impossible to see the name on the board in front of the engine, but the discs or lights can be distinguished, and different combinations and positions are allotted to the different routes. Passengers can learn the code by comparing the discs with the name-plates on the different routes.

WHY TALL PIPES STAND AT STREET CORNERS

At some street corners we see a tall iron pipe standing, often a little higher than the houses round about. This is really a ventilation pipe for the drain, and such pipes are usually seen in districts that have grown up rapidly. The sewers for carrying off the road drainage have been laid not far below the road, and were intended for a more or less rural district. But the building of houses in large numbers and the rising up of a town have made it necessary that there should be better ventilation of these shallow drains, and so the tall iron shafts are put up here and there, and any escape of foul gas passes above the people and their dwellings. Frequently an ironwork guard is placed over the vent at the top of the pipe, to prevent birds building their nests and stopping up the opening.

WHY A POSTMAN'S HAT HAS A PEAK AT THE BACK

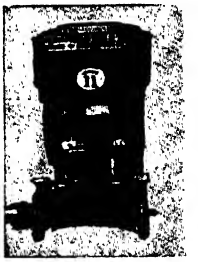
A postman's hat has two peaks, one in front and the other behind, but it is only during recent years that the postman's hat has been given its second peak. Previously there was simply the peak in front; but the postmen suffered so much owing to the unprotected condition of their necks that it was decided to add a back peak for the purpose of shading the neck from the powerful sun in summer, and from rain in winter and at other wet seasons. It must be remembered that postmen have to be out in all weathers. Policemen and soldiers wear helmets, and have the back of their necks protected from the weather.

WHY CASTLE WALLS HAVE SLITS IN THEM

In the walls of all old castles we may see a number of narrow slits called loopholes. These were not so much for the purpose of serving as windows to admit light as to enable the soldiers who might defend the castle in case of attack to fire arrows upon the enemy outside. The narrowness of the slit did not prevent the passing of an arrow fired at close quarters from inside, but it effectively protected the defenders from missiles fired from outside, which would have to be aimed very accurately to pass through the small slits. Sometimes the openings were shaped like a cross, and this enabled arrows to be fired from them in several directions. When they were cross-shaped the loopholes were called ballistraria, which comes from the word for a crossbow. Usually the loopholes widened out at an angle inside the building, so that the very narrow slit was only on the outside of the wall. The battlements at the top of a castle were also to assist in the defence, the soldiers firing through the open spaces.

WHY A MOTOR-BUS HAS A NUMBER

Every motor-omnibus that runs through the city of London has on its front, high up above the driver, a round or oval disc with a number clearly printed on it. The numbers do not go up higher than about thirty, and many omnibuses have the same number on them. These figures are nothing to do with the number of the omnibus itself, but refer to the service, or route upon which it travels. To those who travel regularly into or out of London these figures are a very great convenience, for they soon impress themselves upon the memory; and when an omnibus is coming from the distance at full speed it is not easy to see the names of the places to which it is travelling, but the number can be seen distinctly at a great distance. If we know to what route the number refers, we know whether to hail the driver, long before he comes to the place where we are standing.



WHY A CART'S SMALL WHEELS ARE IN FRONT

As we cannot but have noticed, every four-wheeled van has one pair of small wheels and one pair of large, and the small wheels are always in front. This is not for the sake of appearance, nor is it mere chance that places the larger wheels behind. The small wheels are arranged in front so that the van may be able to turn round, for when the horse is directed to the right or left it takes the shafts with it, and these turn the framework of the front wheels. Being small in diameter, these wheels are able to go under the body of the cart when they are turned, whereas if the larger wheels were in front they would be unable to go under the vehicle, and so the van could not be turned.

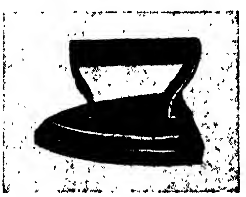
WHY A GRENADIER WEARS A BEARSKIN HAT

THE Grenadiers and men of other regiments of footguards wear large fur hats made of bearskin, which make them look very smart.

But the idea in dressing them in hats of this kind in the first place was not to make them look smart, but to give them a fierce appearance. In the very old days, primitive men who dressed in lions' and bears' skins, would look fierce, and would be known as daring and fearless hunters, and a relic of this idea has come down to our own times in the head-dress of the Grenadiers. John Evelyn writes in his famous diary, in 1678, " Now were brought into service a sort of soldiers called Grenadiers, who were dexterous in flinging hand-grenades, every man having a handful. They had furred caps with coped crowns like janizaries, which made them look very fierce." The Roman soldiers used to put bearskins over their helmets to frighten the enemy.

WHY A FLAT-IRON IS TRIANGULAR IN SHAPE

FLAT-IRONS are almost invariably of one shape, and that is triangular. The reason for this is very much the same as the reason for the bows of a boat or ship coming to a sharp angle, thus forming a wedge. The wedge-like shape of the boat enables it to cut its way through the water, and in the same manner the flat-iron, being triangular, is able to pass over the cloth or garment that is being ironed, pressing the folds and wrinkles on either side, and thus cutting its way through the inequalities of the cloth as a ship cuts its way through the water.



WHY A PAINTER'S PALETTE HAS A HOLE IN IT

THE palettes used by artists are thin pieces of wood, usually of walnut or pear, on which

he mixes his colours as he paints. The palette may be of oval or of oblong shape, but is always hollowed out at one end, and has a hole close by the indentation. When painting, the artist holds the palette in his left hand, his thumb passing through the hole, and the fingers gripping the board where it is hollowed out. Sometimes there is a little pan on the palette to hold the oil, and the colours are at first arranged on the palette in a certain regular order. For water-colour painting the palette is often of porcelain.

WHY BELFRY WINDOWS HAVE SLANTING BOARDS

IF we are interested in fine buildings, we may have noticed that the windows in the upper part of church and cathedral towers are usually fitted with a series of boards slanting downwards towards the ground.

These boards are usually of wood, covered with tiles or sheets of lead, and the proper name for them is abatsons, which comes from a word meaning " to bear down." The purpose for which these slanting boards are fixed in the opening is to throw down the sound of the bells. Were the window merely an opening, the sound-waves of air would pass out and be dispersed, but by striking these slanting boards they are directed downwards, and thus we hear the bells far more plainly than we should otherwise do. In the Middle Ages these abatsons used to have their lead coverings carved and ornamented in other ways.

WHY SOME RAILWAY CARS HAVE A VENTILATOR

WE may have noticed that some of the large wooden railway waggons which carry goods are fitted with ventilators something like Venetian blinds, that can be opened in summer, as shown on the right of the waggon in the picture, or closed in winter, as seen on the left.

The waggons thus fitted are specially built to carry bananas, and the ventilators enable the fruit to be kept cool in summer, and thus saved from ripening too hastily. In winter these same waggons are heated by steam, and so the temperature is kept uniform summer and winter, no matter what the outside air may happen to be. This is essential for the proper preservation of the bananas as they are on their way from the ships to the people who sell them.

WHY SOME SIGNALS HAVE A WHITE SCREEN

It is not at all an uncommon sight to see a clean white board at the back of a signal, as is seen in the case of the lower signal in the picture. The white board is placed in this position in order that the signal may stand out clearly, and the board is kept constantly clean and white. These boards appear in position where there are houses or dark walls behind the signal, which confuse the view and thus prevent the engine-driver seeing clearly and immediately at a glance how the signal is set. Where a signal is high up and stands out against the sky, of course a whitened board is not needed for a background. These boards are usually seen at railway stations, and if the signal is close against a wall or arch, the brickwork itself at the back is often whitewashed.

WHY A BAG HAS A LITTLE FLAP

Leather bags always have a little flap on one side near the catch, and this is not intended as an ornament, but serves a useful purpose. When the bag is shut the two sides fit very closely together, and if the framework sticks at all it would be exceedingly difficult without the flap to open the bag. But holding the handle in one hand and releasing the spring with the forefinger, and then pulling the flap with the other hand, enables us to open the bag with ease. In buying a bag we should see not only that the flap is sound and strong, but that it is sufficiently long to give us a good grip; otherwise it will be useless for the purpose for which it is intended.

WHY SOME BEACHES HAVE TALL POLES

On some parts of our coast, often at lonely places, poles like that shown in the picture may be seen standing, and not many people know what they are for. In some places, as on the Denes at Lowestoft, the pole marks a boundary between two different municipal areas, but it has another use which explains the projections that stand out on either side of it. The coastguards use it as a look-out, and as a place from which to practise with their life-saving apparatus, and the little ledges all the way up are to allow of the coastguards climbing from the ground to the top of the pole.

WHY SOME BARNS HAVE A ROUND OPENING

It will be noticed that many large barns in the country have a small round hole at the end, just below the angle of the gable. This is to allow of the entrance of owls. Great mischief is done to the grain or food stored in barns by rats, and the farmers suffer considerable loss from the raids of these animals but, as owls live largely on rats and mice, it is a great advantage to the farmer if an owl makes its nest in his barn. The birds pounce down upon the rats at night when they are at their damaging work, and so keep down the number of these pests.

WHY SODA BOTTLES HAVE WIRE COVERINGS

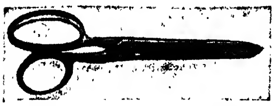
The large bottles in which soda-water can easily be made by means of sparklets are always covered by a network of wire gauze. This is a very necessary addition to the glasswork. In charging the water with gas it is possible, in remote instances, for the bottle to be broken by the discharge of the gas, and, if there were no protecting gauze, the broken glass might cut our hands or fly into our face. The wire netting, however, prevents the broken glass from flying about, and thus makes the bottles quite harmless when in use.

WHY SOME DOGS WEAR HARNESS

We often see pet dogs wearing harness as in the picture. Many people think this is because of some injury that the dog has sustained, and that it serves the same purpose as a leather on a sprained wrist. But the harness is simply in place of a dog's collar, and avoids the strain upon the neck which results when the dog is being led, and has the chain or strap attached to his collar. By using harness instead of an ordinary collar, the strain is distributed more evenly on the body when the dog pulls, and thus the animal is kept healthy.

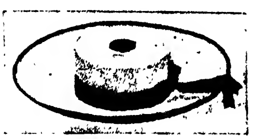
WHY SOME SCISSORS HAVE A LARGE FINGER-HOLE

In most pairs of scissors the two finger-holes, or bows, as they are properly called, are the same size, but in the larger kinds of scissors one of these is larger and bigger than the other. In the ordinary way we can exert sufficient pressure in cutting by inserting the thumb in one hole and one finger in the other, but the pressure required in cutting out thick cloth is considerable, and the force exerted by one finger in bringing the blades together would not be sufficient. So in the tailor's large scissors, and in others used for similar purposes, one of the bows is made larger, to allow of the insertion of several fingers, and in some cases of the greater part of the hand, in order that sufficient force may be exerted to cut through the thickest cloth.



WHY A CHILD'S STRAW HAT HAS STREAMERS

Children's straw hats usually have streamers hanging down behind, or if the bow is at the side the streamers are shorter, and come to the edge of the brim. These ribands are, of course, now only for ornamentation, but they are an interesting relic of a very old custom. Years ago, before the days of modern hats, the head-covering was either part of the robe worn on the body, or was a kind of hood made of soft material; and, in order that this might keep in position on the head, a riband was passed round and tied at the back, the ends hanging down more or less according to the length of the riband. The need for the riband has long since ceased, but the streamers are still found on children's sailor hats and on Scottish caps.



WHY SOME STOCKINGS HAVE "CLOCKS"

We all know the ornament on a sock or stocking which is called a "clock." Why it is so called nobody can say, for the name is one of the mysteries of etymology which no scientist has yet solved. But the thing itself is an interesting relic of the days when the first stockings were made of cloth, and had seams down the sides where the pieces of cloth were joined together. These seams would no doubt be somewhat unsightly and give a clumsy appearance to the foot and leg, and so they were covered with embroidery or other ornamentation to conceal them from view. Of course, now that stockings are woven or knitted, no such need for the clock exists, but, so far from being allowed to disappear, modern stockings often have clocks all round to add to their appearance.

WHY A MAN'S COAT-COLLAR HAS TWO NICKS

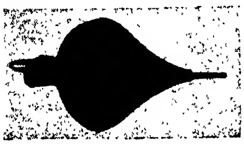
Every boy's and man's coat has a nick in each side of the collar at the front. In some coats, such as in evening dress, the nicks are a mere ornament to relieve the plainness of the collar; but originally these nicks were very necessary, and even now in overcoats they are required if the collar is to serve the purpose for which it exists. When the wind is cold and biting, or when the rain is beating down upon us, we naturally turn our collar up, but if there were no nick we could not turn the collar up without causing the lapels to fold over. In jackets and other ordinary coats the nick is rarely deep enough to allow of the collar being turned up without the lapels being disturbed. In overcoats, however, this is usually remedied by having the nick deeper. In waistcoats, of course, the nick is a mere ornament.

WHY A SHILLING HAS A MILLED EDGE

The milling of the edge of a shilling and of other coins—both silver and gold—is not merely to give an artistic finish to the coins, but for the purpose of preventing crime. In the olden days, before this device had been thought of, dishonest persons used to steal gold and silver from the coinage of the realm, by the simple process of clipping minute portions off the smooth edge of the coins. Gradually, as one and another treated the money in this way, the coins became smaller and smaller, until at last the loss of precious metal became really serious. The milling of the edge of gold and silver coins has effectually stopped this form of crime, for any such clipping of the edge would now be instantly detected, and the coin cease to be legal for circulation purposes. Bronze coins are not milled because the metal is not valuable enough to steal in such small portions as clipping necessitates.

WHY BELLOWS HAVE A ROUND HOLE

We can scarcely have helped noticing that a pair of bellows always has a small round hole on one side, and if we look closely or put our finger into the hole we shall find there is a little flap inside that moves up and down against the hole. The opening is to allow the air to enter the bellows. When we take the handles and pull them apart, thus opening the bellows, air rushes in through the opening, the flap inside being pushed aside by the air as it enters. But as soon as the bellows are full and we begin closing the handles, the air is forced against all the inside walls of the bellows and the flap is pushed down upon the hole, closing it and preventing the air escaping that way. It thus has no other outlet but the nozzle. If the flap inside the bellows is damaged, the bellows are of very little use.



WHY A BIBLE HAS AN ELASTIC BAND

Most of the limp, leather-bound Bibles that we see with overhanging flaps all round have a black elastic passing round them. No matter what the size of the volume may be, whether it be very large or one of the miniature editions that will almost go into the waistcoat pocket, the elastic band is placed round it. The purpose of this is to hold the book together, so that the covers do not get turned back and throw the whole book out of shape. This is particularly liable to occur in a book that has, like the Bibles in question, limp binding and very thin leaves inside. The elastic band also serves the very useful purpose of keeping within the covers of the Bible any loose notes, sermon outlines, and so on, that may happen to be inserted between the leaves.

WHY A SHOEMAKER'S PINCERS HAVE A HAMMER

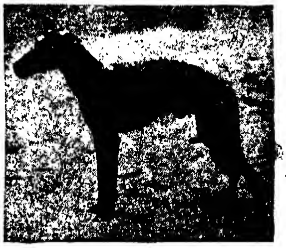
We may have noticed that the pincers used by a shoemaker have a metal projection just under the part with which he seizes any object. This is really to act as a fulcrum, so that when the shoemaker is lasting up a boot—that is, when he is pulling the upper leather tightly over the last to nail it to the insole—he may use the pincers as a lever, and get all the stretch out of the leather. Were it not for the metal fulcrum on the pincers enabling the workman to get the leather tight, our boots would not fit us properly. They would, after a day or two of wear, get very loose, and out of shape. The shoemaker's pincers are really a wonderfully well-adapted tool, for not only does the projection act as a fulcrum, but it is also used as a hammer.

WHY A RAILWAY CARRIAGE HAS A CYLINDER

Underneath nearly every railway carriage we can see a large metal cylinder, and we may have wondered what it is used for. It is the gas-holder of the carriage, and from it the gas passes through pipes to light the various compartments in the carriage. A little dial on the carriage just above the cylinder shows the quantity of gas that is contained in the chamber. These cylinders are filled at the depôt before the train starts for its day's work. Of course, on the more modern carriages that are lighted by electricity there is no need for a gas-holder of this kind, and so it is absent from them. Sometimes the cylinders are filled from large tanks of gas that run upon wheels and can be moved from place to place like ordinary carriages or trucks. We may often see these standing in sidings with a red flag attached to them.

WHY A WHIPPET WEARS A LEATHER MUZZLE

The small type of greyhound known as a whippet, when seen out in a public thoroughfare, is usually wearing a leather muzzle that keeps his mouth quite enclosed. Some people, seeing this, think the dog is vicious and is liable to bite the passers-by. But this is not the case. The dog is wearing a muzzle, not to prevent him from biting people, but to prevent him from picking up any food that may be lying about in the roads or fields. These dogs are valuable, and were they to eat anything unsuitable, or pick up anything tainted in any way, they might be poisoned, or, at any rate, rendered unfit for the races in which they take part. So they are protected from such dangers by the close leather muzzle.



WHY A SAILING BOAT HAS A DRAGSAIL

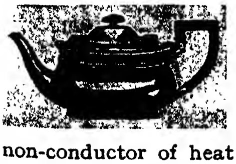
We may have noticed when at the seaside that many of the sailing boats have a curious, pyramid shaped bag, made of sail-cloth, which they throw overboard and drag through the water, the rope attached to it being fastened to the stern of the boat. This bag is called a drag-sail, and the sailors pronounce the word dragsul. It is really a brake, and helps to slow down the speed of the boat. The opening of the bag faces the direction in which the boat is going, and so, of course, the water rushes in and fills the bag, which is thus spread out to its full extent, and makes a load to be dragged through the water. The pull exerted has an appreciable effect in slowing down the speed of the vessel.

WHY A GROOM WEARS A BELT

While a groom is dressed very much like a coachman or footman, with tall hat, doeskin breeches, and top-boots, he wears in addition a leather belt. Many have been puzzled to know what this means, and as a matter of fact it has no meaning at all today. It is a relic of the olden times when ladies used to ride on a pillion, or cushion attached to the back of a gentleman rider's saddle, and, in order that they might not fall off when the horse jumped or galloped, the man wore a belt, which the lady rider could hold. The pillion has disappeared, but the belt is still worn by the groom as it used to be in the days when he took his master's daughter for a ride.

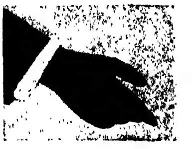
WHY SILVER TEAPOTS HAVE BLACK HANDLES

We must have noticed that most silver teapots, and those also that are plated, have black handles, and even where the handle is of metal there are, at the two places where it joins the teapot, small rings of white or black material. Metal is, of course, an excellent conductor of heat, and when the tea is in the pot the metal handle would get too hot to hold. Instead, therefore, of the metal, some non-conductor of heat is substituted for the handle, and so the teapot can be used quite comfortably. In cases where the handle is of metal, small sections of a non-conducting material are fixed between the pot and the handle, and so the heat is prevented from passing into the handle, thereby rendering it difficult to hold. In many old-fashioned teapots this device was not employed, and the teapot had to be lifted with a cloth "holder" to protect the hand.



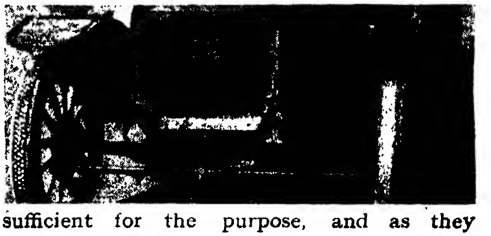
WHY A GLOVE HAS THREE LINES ON THE BACK

In most gloves it will be found that there are three lines of stitching or embroidery on the back, and these are a relic of the early days of gloves. If we open out our hand, we shall notice that there are between the four fingers three V-shaped spaces, and in making gloves in the early days the work was done more or less clumsily, and the stitching of the fingers was carried down part of the way on to the back of the glove, from the point of the V. Then, to cover up the stitching, embroidery was added, and in this way there came to be three lines of ornament. With improved methods of manufacture, the gloves were made much more dainty in shape, and the stitching ceased to go beyond the fingers, but the embroidery was continued as an ornament, and remains so still.



WHY TAXI-CABS HAVE TWO TYRES STUDDED

If we look at the front of a taxi-cab, we shall see that on one side the tyre is an ordinary plain rubber tyre, while on the other side the tyre is metal-studded. Then, if we look at the back of the taxi-cab, we shall see that in the case of the back wheels also one tyre is plain and one studded. The two studded tyres are always on opposite sides of the cab. The reason for fitting the cab with these studded tyres is to prevent it from skidding on asphalt roads, which become very slippery in wet and foggy weather. One metal-studded tyre on each side of the cab is sufficient for the purpose, and as they cost a great deal more than the ordinary plain rubber tyres, these are used for the other two wheels, thus saving considerable expense.



WHY A VIOLIN HAS TWO SLITS

A VIOLIN or other instrument of its class always has two scroll-like slits, or holes, in front of its body on each side of the bridge. Some people think these are merely for ornament, and certainly their shape has been designed to add to the appearance of the instrument. But the slits, which are known as sound-holes, are very necessary to the violin. They enable the sound-waves set up by the vibration of the body of the instrument when the strings are touched to have full scope. Were there no holes in the body of the violin, there would be much less sound by the playing of the bow on the strings, and the sound-waves set up inside the instrument by the vibration would, of course, be unable to escape. Like every other part of the instrument, the sound-holes must be properly cut, and be of the most suitable size, or the instrument will not give out the best sound.

WHY AN UMBRELLA HAS A TASSEL

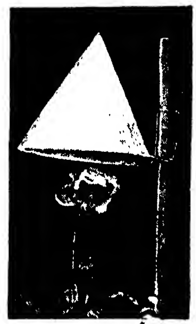
ALL umbrellas, even the cheapest, are supplied with a cord and tassel. This is now purely an ornament, but at one time it served a useful purpose. In the early days of umbrellas, when the ribs were made of whalebone and the covering of gingham, this useful article was a much more formidable thing to carry than it is now, when its compass is that of a walking-stick. The whalebone ribs had a habit of bulging, and in order to keep the umbrella within reasonable limits a cord was carried, attached to the stick, to tie round the ribs to keep the umbrella well together. Tassels were added for appearance. Now, when umbrella rings and metal attachments confine the ends of the ribs, the cord with its tassel is still retained as an ornament.

WHY AN INDIARUBBER SOLE IS ROUGH

INDIARUBBER soles, whether they are on children's sand-shoes or on the shoes used for tennis, are always crossed with a series of diagonal lines, or marked in some other way so that the rubber is given a rough surface. Rubber shoes for grown-ups are used principally for running on grass, and it is necessary that the soles should be marked in this way, otherwise the shoes would be very slippery and give rise to nasty falls. The appearance, too, is much more attractive than would be an absolutely plain surface, and so, although it is not so necessary that children's sand-shoes should be roughed in this way, the practice has been extended to them also; but in the case of the children's shoes the markings are not made so deep as in tennis shoes, and consequently the soles wear smoother much sooner.

WHY SOME GROWING FLOWERS HAVE A SHADE

WE may often see in the gardens of those who pay great attention to the growing of fine rose and dahlia blooms for exhibition at flower shows little pyramidal shades, like tiny umbrellas, fixed over the blossoms. The shade is fastened to an upright stick, and can be moved up and down to different heights as may be needed. These umbrella-like shades are to protect the blooms from the weather—from too much sun, which may affect the colour of the petals, or from too much rain, which may spoil the shape of the flower. The little shades are usually made of white calico stretched tightly upon a pyramidal framework. A rose or dahlia garden with a large number of these bloom-protectors has a very curious appearance. Of course, the shades can be used for other flowers, but it is principally over roses and dahlias that they are seen.



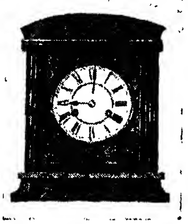
WHY A TRAMCAR HAS WOODEN BARS IN FRONT

IT will be noticed that all the large electric trams, that are such a familiar sight in our cities and towns, are fitted with wooden bars in front, raised only a few inches above the ground over which the tram passes. These bars are to act in the same way as the cow-catcher on an American locomotive. If any obstacle happens to be on the line, the wooden bars push it along in front, and the car does not run over it. This is a great advantage where any man or woman, or boy or girl, or even a dog, is so unfortunate as to fall just in front of an on coming tram. Many lives have been saved owing to the trams being fitted in this way, although, of course, a person falling on the line would not necessarily escape shock and injury altogether.

WHY THINGS ARE DONE

WHY A CLOCK-FACE HAS IIII FOR IV

All our clocks and watches that have Roman numerals on their dials give four strokes for the figure four, instead of the usual IV. As a reason for this an amusing story is told. In 1370 Henry Vick made a clock for Charles V. of France, surnamed the Wise, who wished to live up to his surname, though he had little learning. When the clock was presented to the King, he wanted to show his superior knowledge by pointing out some mistake, so he pointed to the IV, and said it should be four ones. The clockmaker protested that he was right, but the King insisted that the numeral should be altered to IIII, and from that time right down to the present the clockmakers have followed their predecessor's example.

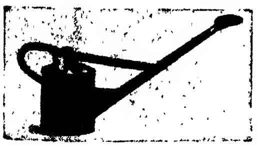


WHY SOME GARDEN ROLLERS ARE IN TWO PARTS

Most of the larger garden rollers have the iron cylinders in two parts, as shown in the picture. This is not the case with smaller rollers, and the reason the large ones are made in this way is that it facilitates turning. When anything is being turned round, the outer portion of it, of course, has to move much more rapidly than the part which acts as a pivot on which the whole is to turn. When the garden roller is made in two parts, therefore, one section can move at a greater rate than the other, and thus the heavy roller can be turned right round without difficulty and without damaging the lawn or path as it moves.

WHY SOME CANS HAVE THE HOLES UPWARD

In some garden watering-cans the rose at the end, instead of being perpendicular, is so arranged that it is horizontal when the can is standing on the ground, and the holes through which the water is to pass point upward. This may seem a strange position for these holes, but there is a good reason for the can being made in this way. When the rose is fixed in the normal perpendicular position the water rushes out with great force, and if very delicate young plants are being watered the force of the stream may injure them. A can is used, therefore, that has the holes upward, and the water then has to force its way up through these, and falls over upon the ground very gently, more like a shower of rain. Some cans have two roses, one like this and an ordinary rose, which can be used alternately as required.



WHY PEOPLE DO NOT PASS UNDER LADDERS

If we stand in a busy street where a house is being repaired, and a tall ladder stands on the pavement leaning against the house, we shall notice that not one in twenty of the people who go by pass under the ladder. Nearly all make a detour and pass on the outside of the ladder. In some cases the reason is, no doubt, a superstitious one, for foolish people consider it unlucky to pass under a ladder, but there is a very good reason for not going under the ladder. The workman up above may, by accident, drop paint or more substantial materials, and if we are underneath we stand a chance of being severely injured. In fact, many people have been permanently injured by things being dropped upon them by the workman as they went under a ladder, and for this reason it is wise to pass outside.

WHY RAILWAY WALLS HAVE LITTLE RECESSES

While travelling by train we may have noticed that where the side of the railway consists of a brick wall, at close intervals there are little recesses in the wall like that shown in the picture. The reason these recesses are built is to provide a refuge for men who may be working on the line. When a train is about to pass they are able to step into one of these little recesses and remain there until the train has gone by. Then they come out and resume their work. The lives of many platelayers and other railway workers have been saved by the provision of these recesses. In some cases the recesses have a wooden screen built in front of them, with a door, and are thus turned into small huts where the platelayers can keep their tools.

WHY A CHEQUE HAS A STAMP

Every cheque, which is really an order to a banker to pay a sum of money on behalf of the person who signs the cheque, has an oval stamp in its top right-hand corner. This stamp is compulsory, and any person drawing a cheque without a stamp upon it is liable to a heavy fine. The stamp is a duty or tax on the cheque, just as there used to be a tax on newspapers, which were stamped very much in the same way. Although for convenience these revenue or duty stamps are specially impressed on the cheques, an ordinary postage stamp is equally legal, provided it is stuck on before the cheque is drawn or filled in. If we look at a postage stamp, we shall see it is marked " postage and revenue," which means that it can be used for the duty as well as for postage. Receipts for amounts of two pounds and upwards must have a stamp on them, for the same reason as cheques are stamped.

WHY A LADDER HAS A BOARD TIED TO IT

Where building operations are going on we may often see, during the week-end or after work has ceased in the evening, a board tied to the lower part of the ladder so as to cover up the rungs, as shown in the picture. This is a practice that has long been carried out, and the purpose of it is to make it impossible for anybody to climb up the ladder without untying and removing the board. At one time, when long builders' ladders were left resting against dwelling-houses at night, there was quite an epidemic of thefts by rogues, who used to climb up the ladders in the darkness and make an entrance through a window while the inmates slept. The board over the rungs prevents this, for to untie and remove it would take a considerable time, and in every likelihood the thief would be caught in the act by some passing policeman or traveller.

WHY A STOVE-BRUSH HAS PROJECTING ENDS

The brushes with which housemaids clean our grates are nearly always of a special shape, like that shown in the picture. The ends are curved, and the bristles put in in such a way that the ends project. The reason for this is that the maid in blackleading the stove may be able to get in between the bars and round the handles of the oven and other projections so as to polish the whole stove properly. It will be seen at once that an ordinary straight brush, like those we use for polishing boots and shoes, would be quite inadequate for the proper cleaning of the stove. Sometimes only one end of the brush has the projecting bristles.

WHY A TELEGRAPH POLE IS FENCED ROUND

Telegraph poles that stand by the side of the road in country towns and villages are usually fenced round in the manner shown in the picture. Before being erected the poles are soaked in creosote, which is a preparation of tar, and has the property of preserving wood. After a time some of the creosote oozes out of the wood, which is then wet and sticky, and passers-by rubbing against the pole would have their clothes spoilt. So, to prevent this, the Post Office authorities have the pole surrounded by a fence made of battens of wood placed close against the pole, and high enough to protect anyone who may knock against it. These fences, or guards, are painted a light colour, usually white or cream, so that they may be plainly seen at night; for, standing as they do at the roadside, they might easily be run into by motors and carts. A pole that has been treated with creosote for preserving purposes will not take the paint, and that is why the batten fence is used.

WHY A SHIP FLIES A FLAG AND BALL

A ship sometimes flies from its masthead a flag and a ball, and these, according to their position, are signals which indicate that the ship has certain urgent needs. When a flag is seen flying at the top with a ball just under it, as in the picture, the meaning is that the ship is aground and needs immediate assistance. If the ball is at the top and the flag underneath, the ship is on fire or has a leak, and wants help urgently. When, instead of a flag, a pointed pennant is flying with a ball beneath it, the vessel is seriously short of provisions, and those on board are in danger of starvation. When, on the other hand, the ball is at the top and the pennant underneath, the ship is giving warning to another vessel that that vessel is running into danger. All mariners know these signals, and from their simplicity they are easily seen.

WHY THE WELSH FUSILIERS HAVE RIBBONS BEHIND

THE officers and staff-sergeants of the Welsh Fusiliers have at the back of the collar of their uniforms a curious bunch of hanging black ribbons. This is called the flash, and is a survival from the days when men wore wigs. The back of the wig had an ornamental bow of ribbon, and when wigs were abandoned and the man's natural hair was fastened in a kind of pigtail, and made to shine with pomatum, a bow similar to that of the discarded wig was fastened at the collar to protect the coat from being spoiled by the grease on the pigtail. The pigtail has disappeared, but the protecting ribbons are still retained in the uniform of this corps.

WHY THE TOP OF A BOOK IS GILDED

MANY books that are elaborately or gaudily bound have all the edges of their pages gilded, in order to add to the rich appearance of the volume. But in books that are quite plainly bound, and make no pretence to richness in their appearance, very often the top edges of the pages are gilded. In such cases it is for utility rather than for appearance that the gold is added. The thin layer of gold, being metal, is shiny, and any dust that may accumulate upon it when the book is standing on a shelf can easily be dusted off without leaving any mark or stain, whereas if the leaves were left unguilded their white, clean appearance would soon be spoilt by the dust.

WHY A HORSE'S HARNESS HAS BRASS CRESCENTS

MOST of the harness worn by cart-horses is ornamented more or less with little brass discs or crescents. Frequently there is quite a chain of these hanging down in front of the horse, as shown in the picture, and the most common shape is the crescent. The origin of these dates back to the Middle Ages, when the Moors were very powerful and had a great influence on European civilisation. The Moors used to put these brass crescents on their horses, not merely as ornaments, but as amulets to protect them, as they thought, from evil influences. The Moors were, of course, Mohammedans, and the crescent was their sacred symbol, and in placing the brass ornaments on their horses they were only doing what ignorant and superstitious people do in some Christian countries today when they hang a cross round a child's neck to preserve it from harm. Even the plainest harness usually has some of these ornaments.

WHY SOME CHAIR-LEGS ARE JOINED BY BARS

IN many cases the legs of chairs are joined together by one or two bars. This is particularly to be noticed in the case of kitchen and office chairs, or any seats that are required for hard wear, and the reason is, of course, to add strength to the chair and prevent the legs spreading apart. In good dining-room and drawing-room chairs, which will be treated with care, these bars are not often found, although sometimes, when a drawing-room chair is made very fragile, with thin legs, long in proportion to the side of the seat, bars are added to strengthen these thin legs. In some cases, too, a certain style of inlaid chair has the bars added, as much for appearance as for strength, but as a general rule the bars are added simply to give strength.

WHY A COLLEGE CAP HAS A STIFF BOARD

WE are all familiar with the curious college cap called a mortar-board, which is worn by undergraduates, schoolboys, and others. The square, stiff board on top of the cap, to which the tassel is attached, seems to have no reason for its existence. As a matter of fact, its origin can be traced back to Tudor times, when the soft cloth caps worn by ecclesiastics were gradually increased in size until the folds of cloth became so large that they were inclined to flop down all round the cap. These folds took a more or less square shape for convenience—we usually fold things square, such as table-napkins handkerchiefs, and so on—and when the hanging down of the cloth became a nuisance the idea of stiffening it seems to have occurred to someone. Gradually the folds of cloth became a stiff board attached to, but quite independent of, the cap itself.

WHY A MAN HAS A BOW INSIDE HIS HAT

A MAN'S hat, whether it be a tall hat, a bowler, or a Trilby, has a small silk bow inside, attached to the lining, and very often the ribbon is laced in and out of the lining for a short distance on each side of the bow. This is a survival from the days when men could not get hats that fitted them as well as they do now, and so a lace was passed right round the lining, and could be pulled tight or let loose, according to need. The lace is still preserved in hats used for hunting, and the lining can be let out or pulled tight to grip the wearer's head. The hat is thus prevented from blowing away. Of course, in ordinary hats the lacing of the silk ribbon and the bow are now only for show, and have no real use whatever.

WHY SCISSORS HAVE ONLY ONE BLADE POINTED

IN all the scissors used for ordinary purposes one of the blades is pointed and the other rounded at the end. The reason for this is that such scissors are intended for general use, and this arrangement of the blades is very convenient. The pointed blade can be stuck through a piece of linen or cloth, and thus a hole can be cut out in the material. On the other hand, if it is desired to cut up a length of cloth or to cut out a garment, by turning the scissors over they can be run along the material quickly, cutting it as required, the rounded end gliding smoothly over the table and not sticking into it as the pointed blade would do. Of course, for special purposes, some scissors are made with both blades pointed, and others with both blades rounded. Nail scissors, surgical scissors, buttonhole scissors, and so on, all have their special shapes adapted to their peculiar uses.

WHY ONE BOAT OF A SHIP IS TURNED OUTWARD

ON most large liners and on all big warships one of the boats is always hung outward over the sea, although the other boats are usually turned inward and hang over the deck. The davits on which the boats are suspended work on pivots, and can be turned in or out, but they are usually turned in for safety. Were they all projecting over the side of the ship, they would probably be damaged or washed away by heavy seas in times of gale. One boat, however, is kept turned outward on either side, so that, if anyone should be so unfortunate as to fall overboard, the boat can be instantly lowered for purposes of rescue. Many times this simple provision of readiness has been the means of saving a life which would otherwise have been lost. With the tremendous increase in the size of modern ships, it became a much more elaborate business to let down a boat than it used to be in smaller vessels.

WHY SOME GUARDS HAVE THEIR BUTTONS IN TWOS

WE may have noticed, when watching the men of various regiments of Guards marching through the streets or keeping the route for a royal procession that they have the buttons of their coats arranged differently. The Grenadiers have theirs like any ordinary man's coat—that is, at regular and equal intervals from top to bottom. The Coldstream Guards have theirs in pairs, the Scots Guards in threes, and the Irish Guards, the last regiment of Guards to be formed, in fours. There is no reason for this curious arrangement other than to give some distinguishing feature by which the different Guards can be known. The uniforms of the four regiments have one or two other slight variations, as in the colour of their plumes.

WHY AN EIDERDOWN QUILT IS STITCHED ALL OVER

AN eiderdown quilt is, as we know, stitched all over, so that the quilt is divided into sections. This is to prevent the down from slipping to one side or corner, and accumulating there into a hard pressed mass. as it would do were there not these rows of stitches to prevent it. By keeping the quilt in sections, the down is distributed evenly all over it, and the quilt thus serves its purpose. The stitching is not done in straight lines, except round the border, but is curved about, so as to form some sort of design. The principle is really the same as that adopted in the case of air pillows and beds, already described.

WHY AN EXPRESS ENGINE HAS A LOW FUNNEL

We cannot have failed to notice that the funnels, or chimneys, of express locomotives are very short, rising in some cases not more than a foot above the main body of the engine. These express engines, in order to be able to do the work required of them, have to be made very powerful, and as a result they are much larger than ordinary engines required for short distances and local traffic. If the funnel were to be as large in proportion as those of other engines, it would rise so high as to knock against the bridges that cross all railways at various points, and would also be too lofty for many of the tunnels. The chimney is therefore made very low, so as to clear these overhead obstructions.

WHY A PEN-NIB HAS A SLIT

All pen-nibs have a slit running to the point from a little round or oval hole which is cut in the middle of the nib where it begins to taper. Were it not for this slit, and the fact that the whole body of the nib is curved, we should be unable to write. The curvature causes the nib to hold a considerable quantity of ink when it is dipped in the pot, and the slit causes the point of the nib to open into two sections when it is pressed upon the paper, and the ink between these sections is then left on the paper, forming a line or letter, as the case may be. Steel nibs also have two little slits in their sides or shoulders. These are to give greater flexibility to the nib. Gold nibs, being softer, do not need these side slits.

WHY A FEEDING BOTTLE OPENS AT BOTH ENDS

The boat-shaped feeding bottles that are so generally used nowadays, and have almost driven out the old style of bottle, with its long, unhygienic rubber tube, is open at both ends, although, for the purpose of pouring in the milk, one open end would be sufficient. There are two reasons for this. In the first place, the bottle is open at both ends for sanitary purposes. If it opened at one end only it could not be cleaned properly, for a continuous stream of clean water could not be run through it from end to end, as is possible now. This is the great objection to upright feeding bottles. Then, in the second place, the baby used to have great difficulty in drawing the milk out of the old bottles, which were open only at the top. The pressure of the atmosphere on the milk makes it easy for the baby to draw it through the opening at the opposite end.

WHY SOME HORSES' TAILS ARE DONE UP IN STRAW

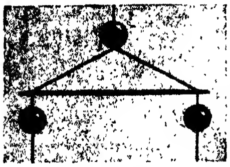
We often see cart-horses going to market with their tails and manes done up in a kind of plait with wisps of straw. The reason for this is to keep the hair clean. These horses usually have long tails and manes, and were they allowed to hang loose they would get dirty and take something from the fine appearance of the horse. So they are done up to make them look clean and smart. It has been thought that the use of straw in this way is a relic of the old pagan days, when horses were sacrificed in order to secure a good harvest for the farmers, and when these useful animals were looked upon as creatures in which dwelt the spirits who presided over the growing and ripening of the corn. No doubt straw played an important part in the sacrifice of the horse.

WHY A LANCER'S HELMET HAS A SQUARE TOP

The helmets which lancers wear in this and other countries are quite unlike all other helmets in shape. Instead of having a rounded top surmounted by a spike, a knob, or a plume, they are square at the top and the plume is fastened to one angle of this square. The reason for this peculiar shape of the lancer's helmet is that it is really the national hat of Poland, and the earliest lancer regiments in the modern sense were made up of Poles. Their system and methods were copied by other nations, and the dress which they wore in their native country was also imitated. The style of the uniform is really Polish, and the helmet, or shapka, as the Poles call it, was originally a round cap with a kind of concertina top that could be pushed up and down. The top is now stiff. The English lancers, who were first formed in 1816, retain the original size of the square top, but Continental lancers have reduced this considerably.

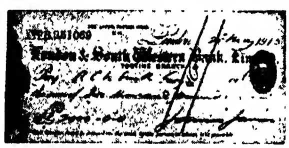
WHY A SIGNAL STATION HOISTS THREE BALLS

SOMETIMES we may see at one of the many signal stations round our coasts three balls hoisted on the mast, as shown in the picture. The meaning of this is that telegraphic communication is interrupted, and that messages from the ships cannot be forwarded by telegraph, and will have to be transmitted by other means. The balls are kept hanging in this position until communication is restored. At night three green lamps are arranged in the same way, as a triangle, to show that the telegraph is interrupted. When only two balls are hoisted—that is, the signal already described without the top ball—the meaning is that the signal station is temporarily closed, and in this case also the balls are exhibited in this position until the station is once more doing duty.



WHY A CHEQUE HAS LINES DRAWN ACROSS IT

IN most cases bank cheques have two lines drawn across them from top to bottom, and the letters " & Co." written between the lines. This means that the money which the cheque represents will only be paid if the cheque be presented through a banker. It cannot be taken direct to the counter of a bank and the money demanded on its presentation, but must be paid in and pass through a banking account. If the name of a particular bank is written between the lines, then the money can only be obtained by paying it into that bank. This crossing of a cheque enables whoever drew and signed it to trace through what hands it has passed up to the time that it was cashed.



WHY A FUNERAL HORSE WEARS FEATHERS

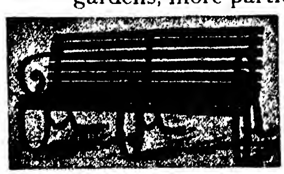
IT is still quite a familiar sight to see a funeral horse wearing a plume of feathers on its head and various other elaborate trappings about its body, though this kind of thing is not so common as it was some years ago. It is really a survival from the days of chivalry, when, at the funeral of a knight, his arms, crest, and other insignia accompanied him to the grave, and his horse, fully caparisoned as though for a tournament, was led in the procession. The sight of such trappings was considered impressive, and the practice gradually extended until it was carried out by all who could afford it at a funeral of a near relative. The tendency nowadays, however, is towards greater simplicity, and no doubt before long the practice of elaborately adorning the hearse and the horses at a funeral will almost entirely die out.

WHY A BLUECOAT BOY WEARS NO CAP

THE most striking feature of a Bluecoat boy, after his curious uniform—yellow stockings, blue gown, and leather belt—is the absence of any head-covering. The uniform, with one or two slight modifications, dates back to the time of Edward VI., when it was the ordinary dress of the period. The Bluecoat boys originally had caps, red at first and then blue, but for some reason, which cannot be explained, they were made small, and by the middle of the nineteenth century they had become so small that they were practically useless as head-coverings. The boys then used them chiefly for getting a drink of water at the pump in their playground. They had long since ceased to wear them, and so the authorities decided to abolish caps, and they are not now served out to the boys at all. So far from suffering any ill-effects from thus leaving the head uncovered, the Bluecoat boys have found the practice a healthy one and helpful to the growth of the hair.

WHY GARDEN SEATS OFTEN HAVE ROUNDED FEET

MANY of the seats seen in parks and gardens, more particularly those that stand on grass, instead of having the usual four legs like indoor seats, have their feet rounded as shown here. There is a very good reason for this. In rainy weather, when the ground is soft, the ordinary legs would sink into the soil and damage a lawn or grass plot. By rounding the part that stands on the ground a wider surface is presented, and the seat does not sink into the moist soil. Sometimes the same result is obtained by having ordinary legs to the seat, but screwing these to a broad plank of wood, each pair of legs being joined by one plank.



WHY A BISHOP'S HAT HAS STRINGS

The tall hats worn by bishops have on either side little strings connecting the crown with the brim. These are merely

an ornament now, but at one time they served a useful purpose. Bishops in Tudor times wore soft cloth caps, and these were gradually increased in size, and folds of cloth added, until the sides flapped over and hung down in a very uncomfortable manner. To prevent this, in some cases the cloth was stiffened and developed into the mortar-board, or college cap, as already explained, and in other cases the overhanging flaps were held up with laces or strings attached to the top of the cap. With the stiff brims of modern tall hats these strings are no longer wanted, but they are continued as part of the uniform of a bishop, and form an interesting survival from olden times.

WHY SOME PLATFORMS HAVE WHITE EDGES

At some stations, particularly on the underground railway in London, it is the custom to whiten the edge of the platform, as seen in this picture.

This practice will usually be found at stations that have difficulties of lighting or where there are shadows cast by pillars and other obstructions, and the purpose of it is to make the edge of the platform very plain, so that no passenger shall step off it by accident while waiting for a train. Since stations have been so much better lighted than they used to be, the practice has not been followed as much as was once the case. With the advent of electricity and the improvements in gas-lighting, there is no excuse for dark stations.

WHY CRICKET STUMPS HAVE METAL TOPS

All cricket stumps used by men in proper matches, and most of those used by boys, have metal caps fitted to them at the

top. The cap is grooved so as to allow of the bails resting steadily at the top of the wicket. The reason for the metal cap is to lend strength to the stump, as well as to improve its appearance. Were the wood unprotected, the constant hammering of the stump into the ground with a mallet, especially in dry weather when the ground is hard, would either split the stump altogether or would flatten it out of all shape at the top. This difficulty has been overcome by putting the metal cap over the wooden stump, which acts as a binder to the wood and forms a hard head for the mallet to strike.

WHY A HUSSAR'S TUNIC HAS HORIZONTAL LACING

We all know that the various regiments of hussars in this and other countries, and the men of the Royal Horse Artillery, wear horizontal lines of braid on the front of their uniforms.

These have developed from buttonholes in the times when the tunic was kept open by fastening back the front in two flaps to right and left. They have now, however, ceased to be buttonholes at all, and are exaggerated out of all recognition. It is suggested that the reason for developing them in horizontal lines was to give them the appearance of ribs, and thus add a terrifying appearance to the soldier. The suggestion is rather supported by the fact that the early hussars wore the representation of a skull on the front of their fur busbies, and on the Continent some regiments do this even now.

WHY A BIG SHIP HAS THREE KEELS

All big warships and many large merchant vessels have, in addition to the ordinary keel at the bottom of the ship, two other keels, one on each side below the water-line, which are known as bilge keels. They are

fitted in order to reduce the rolling of the vessel, and their success in this is remarkable. Bilge keels add greatly to the comfort of passengers travelling by the large ocean-going liners, but they are of the greatest importance to warships, as, owing to the reducing of the rolling, much more accurate gun-firing can be achieved. The bilge keels are sometimes three or three and a half feet in width, and vary in length from one-third of the vessel's length to nearly its total length. It was at first thought that bilge keels would reduce the speed of vessels, but this is now proved not to be the case.

WHY A MAN'S COAT HAS BUTTONS ON THE SLEEVE

A man's coat-sleeve always has a number of buttons, varying between two and four; and sometimes there are real buttonholes, so that the cuff can be undone, while at

other times the buttonholes are only dummies. These are a relic of the days when men's coats were much more elaborate than they are now. The sleeves were very richly embroidered; and in order that they might not be spoilt, when a man was eating he used to turn the cuff back and button it some distance up his arm, so that it should not rub against any greasy dish on the table. After a time the sleeve was permanently buttoned back, and the cuff was lengthened, the buttons and buttonholes becoming mere ornaments. In indoor coats we have dropped the cuff, but we still retain the buttons for adornment.

WHY A COACHMAN'S BOOTS HAVE YELLOW TOPS

When top-boots were first worn they were made to come far above the knees, as may be seen in old pictures, and the nearest approach to these original top-boots are the long waterproof boots

worn by the men who work in sewers. The tops, however, were made to turn down, and were often worn in that way, so that the lining of the boot showed at the top, and also the tags by which they were pulled on. Gradually this turning down of the boot-top became permanent, and the contrast of colour was emphasised by the top being made, as in a coachman's boot, of very light yellow. The tags, too, came to be sewn down on the outside of the boots as ornaments, and fresh tags were placed inside for use.

WHY A MAN'S WAISTCOAT IS OPEN AT THE TOP

With the exception of soldiers and clergymen and uniformed servants, most men wear coats and waistcoats that are open for

some distance at the top, showing the shirt-front, and in evening dress this opening is carried down almost the whole length of the shirt-front. Although few are aware of the fact, this exposure of the shirt is really a survival from the time when it was considered a badge of respectability to be able to show a shirt at all. Linen was dear, and only those of some means were able to afford white shirts, and any man who had linen was only too proud to exhibit it.

WHY SOLDIERS HAVE STRIPES ON THEIR TROUSERS

Soldiers always have a coloured stripe down the outside of their trousers, and this feature is also seen in official

uniforms, where the stripe is usually of gold braid. This is merely for ornament, but it is said to be a very interesting survival of the days when men's trousers were made so tight that they could not be put on in the ordinary way. The legs had to be unbuttoned right down, and then when the trousers were on they were buttoned up again. In order that the buttons might not be seen, a fly of cloth often covered them, and it is really this fly, or covering, that has survived in the modern stripe of braid. The row of buttons from top to bottom of the trouser-leg may often be seen in pictures of cavalry soldiers of the end of the eighteenth and beginning of the nineteenth centuries.

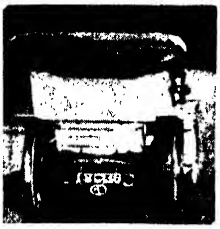
WHY A MATTRESS HAS LEATHER BUTTONS

The mattress of a bed always has a number of small leather discs something like buttons scattered over its surface. These are not

for ornament, but serve a very useful purpose. If the material with which the mattress is stuffed were simply put into the case or cover with no means for keeping it evenly distributed, the mattress, instead of being flat and comfortable, would be like a big bag, and all the material would work down to one end or corner, like it often does in a feather bed. The bed, however, can be shaken up, and the feathers separated and distributed evenly, whereas the material in a mattress would be compressed into a hard lump, and could not be shaken apart. The mattress is therefore sewn through with string at intervals, and the stuffing is thus kept evenly distributed in small compartments. In order that the string may not cut through the outer covering of the mattress, it is fastened to the small discs of leather on either side.

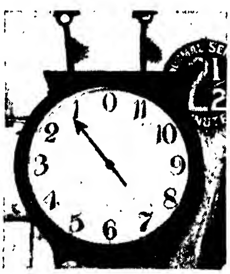
WHY SOME MOTOR-CARS HAVE THE LETTERS "G.B."

We may have noticed on some motor-cars the letters "G.B." placed against the registration number. These letters are in addition to the letter or letters which indicate the particular district of the country in which the car is registered under its special number. Whenever we see the letters "G.B." on a car, we may know that its owner is a traveller, for the initials stand for Great Britain, and the letters are carried, when the car is on the Continent, to indicate the country to which it belongs. Where a motorist is often going backwards and forwards to the Continent, he usually leaves the letters on his car.



WHY A STATION HAS A CLOCK WITH ONE HAND

At many of the Tube stations in London a curious clock-face will be seen at the end of the platform, with a single hand that moves backwards and forwards, but does not indicate in any sense the true time. The figures on the dial run round from right to left, instead of from left to right, as on an ordinary timepiece. This clock is not meant to indicate the time at all. It is really placed where it hangs for the use of the drivers, who can tell by the distance of the hand from the nought, or zero, how many minutes previously the last train passed out of the station. As each train passes, the hand goes back to nought, and then begins to move to the left as the minutes pass, until another train leaves the station. These clocks are known to the railwaymen as headway clocks.



WHY THE BOTTOM OF A TIN IS RIDGED

If we look at the bottom of a tin such as is used for golden syrup or canned fruit, we shall notice that it has ridges running round it. These are generally supposed to be merely for ornament, but such is not the case. In the stamping out of the bottom, these ridges are impressed in the metal to add strength to the tin when it is made and filled with its contents. The ridges really embody the principle of the arch, and, as we know, an arch is one of the strongest and most wonderful of architectural devices. In small tins and those containing light powders, the ridges are not usually found, as they are not needed for strengthening purposes. The stamping of these ridges in the metal is of great importance in the packing of food, as it enables a thinner and cheaper tin to be used, and thereby enables the various articles of food to be sold at a lower price than they would otherwise be sold.

WHY ETON BOYS WEAR BLACK COATS

In these days when the old, gloomy ideas about deep mourning have almost passed away, it seems strange that there are still many who are wearing mourning for someone who died nearly a hundred years ago. Yet such is the case. The boys of Eton School, both juniors and seniors, wear black coats, and they have done so since 1820. In that year they went into mourning for King George III., adopting black coats and tall hats, and they have never gone out of mourning. Previously, they wore mortar-board caps, and their clothes were not dark. The curious little pointed jackets that the smaller boys wear are a continuation of the shape jacket that was the fashion a century ago, and the wide collars worn outside the coats are a relic of the lace bands that used to be so favoured in olden times.

WHY A BOOTLACE HAS METAL TAGS

The ends of our boot and shoe laces are always finished with a metal tag. This is entirely for use, and not at all intended as an ornament. Were it not for the tags the ends of the lace would fray and unravel, and, as we very soon find out if we lose the tag, prove very difficult to pass through the eyelet-holes. The tag, being of the smallest possible diameter, and holding the end of the lace well together, enables us to lace up our shoe without difficulty. It is curious that these tags of boot and shoe laces should have remained of the simplest possible nature, for a century or two ago, when laces were largely used in place of buttons for fastening clothes, the tags were made ornamental, and often took the form of little figures.

WHY A CARMAN'S COAT HAS A LEATHER SHOULDER

MANY of the drivers of railway luggage vans and other carmen have a large piece of leather let into the shoulder of their coats or sewn over the cloth.

These men have to lift and carry very heavy packages, and if they wore an ordinary cloth overcoat the pressure and rubbing of these packages would soon wear out the shoulders of their coats. The leather is therefore added to strengthen the garment, as, among pliable materials that can be used in this way, it is perfectly true that there is nothing like leather. In some cases, instead of having the leather sewn upon the coat, the carmen have a kind of leather pad strapped to the shoulder, and this, of course, serves the same purpose, and can be removed when heavy packages are not being carried.

WHY A HUSSAR OFFICER'S BELT HAS PRICKERS

IF we look at the front of the belt that goes over the shoulder and round the body of an officer of the hussars or other light cavalry regiments, we shall notice two small arrow-like attachments fastened with little silver chains.

These are called prickers, and are a relic of the old days when flint-lock, muzzle-loading muskets were carried by soldiers. In order to clear the touch-hole each time after the weapon had been fired, a sharp instrument something like a shoemaker's awl was used, and, in order that it might always be ready to the hand, it was attached to the pouch-belt. In case one should get broken, a couple were carried, and, although the instruments are no longer needed, they have been retained as ornaments, and have gradually grown more decorative.

WHY ONE SHEAF IS LEFT IN A REAPED FIELD

AT harvest time we often see, in a field that has been reaped and cleared of its wheat or barley, a single sheaf left in the middle of the field.

This is a warning to gleaners that they must not yet enter the field, as it has not been raked by the farmer. Many people think that gleaners have a legal right to go into a reaped field and gather up any stray corn that may have been left after the crop has been carted, but such is not the case, and any farmer may prohibit gleaners from coming into his fields. It is not often, however, that such prohibition is issued, the cottagers being at liberty to enter and gather what they can after the field has been raked.

WHY A SHIP'S BOWS HAVE A SHARP EDGE

THE bows, as the front part of a ship or boat is called, invariably have a sharp edge, and there is a very good reason why every vessel, large or small, should be built in this way.

The ship has to cut its way through the water, and, in order that it may do this with the greatest possible ease, the front of the vessel is made in the form of a wedge. The principle upon which the ship cuts its way through the water is exactly the same as that upon which the hatchet cleaves the wood or the knife cuts the bread. A punt, of course, is not meant to be driven through the water at even a moderate speed. It is simply a kind of raft in which one can lie and move lazily along at the least possible speed, and in this case the front is square. But a punt is not really a boat.

WHY A LANCER HAS STRINGS TO HIS HELMET

THE helmet of the lancer, which is so curiously shaped, has a peculiarity which is strikingly noticeable. Attached to the helmet is a long cord which passes round it, and is then carried under the right shoulder-strap, round the body, under the left arm, and under the right shoulder-strap again, being finally attached to the left shoulder-strap.

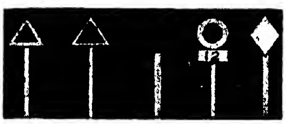
This large cord is said to be a survival of a long-ago day, when lancers, being mounted on light, swift horses, used to be sent out to forage for the army. Anything they could find in the way of food was easily seized upon and brought into camp, and, in order that they might be able to tie up bundles of corn or grass, they carried the long cord, which often came in very useful. In these days of commissariat departments, when the needs of an army are specially catered for, there is no need for the cord, but it is still retained as an ornament.

WHY STONE STEPS ARE FOUND BY SOME ROADSIDES

In many quiet provincial towns and in rural districts there will often be seen by the roadside a stone in the form of two or three steps, reaching in height to three or three and a half feet. These stones are often very much worn, so that the tops of the steps are almost basin-shaped. They are a relic of the distant days when nearly everybody who wanted to travel a distance used to ride on horseback. Men, of course, could mount easily by the stirrup, but it was not so easy for a lady to get upon her horse, and so these stone steps were placed at various points, and ladies were enabled by these means to mount and dismount with comfort and without assistance.

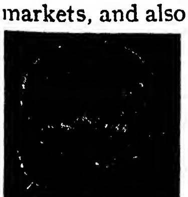
WHY MOTOR SIGNS ARE PLACED ON ROADS

There are a number of curiously shaped signs that stand by the sides of roads to warn motorists, and we may perhaps wonder what those different shapes are meant to convey. A hollow, red, equilateral triangle is to caution drivers of dangerous corners, crossings, or hills some fifty yards ahead. A dark triangle painted on this same sign indicates that the danger ahead is particularly acute, and greater care than usual must be taken to slow down. A solid red disc about eighteen inches in diameter is an absolute prohibition; while a white ring with a plate below containing a number is a warning that speed must not exceed so many miles an hour, the rate being indicated by the figure on the plate. Special cautions, such as "School," "Church," and so on, are printed on horizontal boards. All other signs are placed on diamond-shaped boards.



WHY A FRUIT BASKET HAS AN ARCHED BASE

The large fruit baskets which we see at Covent Garden and other produce markets, and also at the greengrocers' shops, always have their bases made in such a way that they dent upwards in a more or less cone shape. Some people think that this is really a trade trick, and is done for the purpose of conveying the idea that the basket holds more than it actually does. But such is not the case. The bottom is arched in this way to keep it well off the ground, and only the rim of the base, which is woven in a particularly strong way, touches the ground. If the whole of the bottom of the basket stood upon the ground the base would soon wear out, and when the basket stood in a wet place the fruit inside would spoil. By arching the base this is avoided.



WHY A HOUSEMAID WEARS A CAP

The wearing of a white cap by a domestic servant is connected with the practice common in the case of menservants, of those who serve in a menial capacity wearing a uniform to indicate their calling, and is a relic of the days when all who served under a master wore his heraldic colours or device. The women usually wore linen, and the head-dress was regarded as a sign of submission, which was the real origin of females retaining their hats in church. The same idea led to the wearing of the cap permanently by female servants. The strings which often hang down the back from the cap of a domestic servant are a survival of the string that once was laced round the head-dress to pull it in to fit the head.

WHY A ROUNDED STONE STANDS AT STREET CORNERS

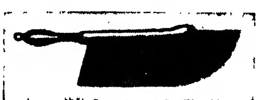
We often see a stout rounded stone standing at the corners of streets, particularly in quiet provincial towns, and if we take notice we shall find that these are usually at places where there is a very sharp turn or some other dangerous condition. The reason for placing the stone in position is to prevent accidents. A heavy waggon going round the corner might be liable to jump the curb and get upon the path, but by placing these stout stones at the corners such a danger is avoided. We have already mentioned in these pages that old cannon and posts of a similar shape are placed at dangerous street corners in cities and towns for a similar purpose. With the advent of motor-cars and the more even steering the need for such guards has largely disappeared.

WHY MOST TINS ARE ROUND

If we look in a grocer's shop, or in any other place where there are various brands of articles packed in tins, we shall find that by far the larger number are placed in round tins. This is especially the case with large-size tins, and there is a reason for it. It may be the case that round tins are made a little more easily than square ones, but the main reason for the very common use of this shape is that it is the strongest that can be made. The roundness embodies the principle of the arch, with all its strength, and round tins can be subjected to a great deal of knocking about and pressure without being seriously pushed out of shape. The ways in which the principle of the arch enters into our everyday life are far too numerous to mention, but this is a striking example.

WHY A STAIR BROOM HAS PROJECTING BRISTLES

The short hand brushes for sweeping floors and carpets that are used by the maids in our houses always have the bristles, whether they are soft or stiff, sticking out in front. To those of us who are not in the habit of using a broom or floor brush ourselves, this may seem unnecessary; but it is really most useful. If we watch the maid sweeping out a room, or cleaning down the staircase, we shall at once see the reason for the projecting bristles. They enable her to sweep out the corners and angles of the room, and to get between the banisters of the staircase, where the wooden head of the broom will not go. By fitting the bristles into the wood in this way, a second brush for corners and banisters is rendered unnecessary. The use of a similar arrangement on a stove brush to enable the maid to clean between the bars of the grate has already been referred to.



WHY A WHEELBARROW HAS ONLY ONE WHEEL

While we all know quite well that a wheelbarrow has only one wheel, we may never have considered that there must be a reason for this. There is really no other kind of vehicle or conveyance that possesses only a single wheel. The reason becomes clear when we remember the use to which wheelbarrows are put. They are used principally in gardens and for building purposes, the labourers pushing bricks and other articles from place to place along narrow planks and gangways. In gardens, too, the barrow is pushed in and out of narrow and winding paths, and it is this special use of the wheelbarrow that led to its being fitted with a single wheel.

WHY SOME TELEGRAPH POSTS HAVE SUPPORTS

We often see the telegraph posts that stand by the sides of railways and on country roads fitted with supports, as shown in the picture. These supports are placed in position at spots where the strain on the pole is more than ordinary. Sometimes the extra strain is due to a bend in the road or track, when the wires slanting off on each side are pulling the pole in the same direction, and if it were not especially supported would soon be dragged over. The weight of the wires themselves is, of course, very great, and when the wind is blowing upon them this weight is greatly increased. The pressure upon the pole, when it stands by a railway, is also added to by the vibration caused by the trains, and if the soil is very wet, or shrinks owing to extra dryness, the pole is soon worked loose. Of course, wherever possible, the wires are carried straight, but this is not always possible on railways.

WHY A BISHOP WEARS GAITERS

As we know, an English bishop wears, as part of his regular ecclesiastical costume, knee-breeches and leggings. These leggings, or gaiters, are a relic of the dress of a bishop worn in the days of long ago. The first mention we find in history of a bishop wearing leggings is in the twelfth century, but then they were of linen. Later on they came to be made of silk, and boots buttoned up the side were worn. Gradually the present gaiter, reaching from the boot to the knee, was evolved, and, having an ecclesiastical appearance owing to its association with bishops, its use was extended to deans and archdeacons, who still wear gaiters just as a bishop does.

WHY POSTS WITH TRIANGLES ON TOP ARE SEEN NEAR THE SEA

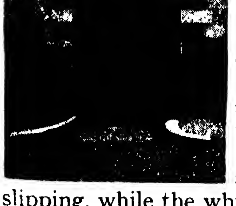
On the seashore in the North of England, near the great shipbuilding yards, posts somewhat similar to the picture may be seen here and there, and wherever one is we may be sure to see another just a mile away. These posts are really milestones, placed in position to mark off an exact mile. When a new ship has been launched and fitted with her engines she is ready for her speed trials, and it is necessary to have a space definitely marked off, so that the time she takes to go a mile may be discovered. The vessel is timed, as she travels through the sea, a distance equal to the space between the two posts on the shore, which is the measured mile.

WHY POULTRY CARVERS HAVE SHORT BLADES

If we look at any case of carvers containing two sets, we shall notice that while in one case the knife has a short blade, its fork corresponding in proportion, the other knife has a long blade, with a fork similarly proportioned. The long-bladed knife is, of course, for use in carving joints, and this blade enables the carver to make large, clean, sweeping cuts. If the blade were short, the slices of meat would be jagged when cut. On the other hand, for carving poultry, where we cannot get fine, large cuts, and considerable strength has to be exercised to separate the various parts of the bird, a handle almost the length of the blade gives a good grip to the carver, and a short, strong blade, which will not bend like that of an ordinary carving-knife, enables us more easily to exercise the necessary pressure.

WHY SOME CURBS ARE WHITEWASHED

We often see the curbs on either side of the roadway leading into a livery stable whitened, and fine sand put down in the road. These precautions are taken to help those using the stables. The sand on the roadway, of course, helps the horses to get a grip, and prevents slipping, while the whitened curbs on either side show up plainly, and enable the driver to guide his vehicle into the stable-yard without scraping the wheels against the stonework. They also, by their prominence, act as a warning to pedestrians, and suggest that care be taken to look out for vehicles likely to be passing in or out of the stable-yard. In high class livery stables the whitening of the curb and sanding of the road are renewed every day.



WHY WOODEN BOXES STAND ON RAILWAY TRACKS

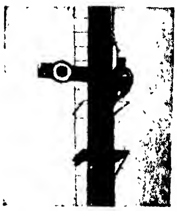
If we travel much by train we shall have noticed that at various points little white wooden boxes or coverings are placed close up against the lines on the railway track. These are usually of the shape shown in the picture, and if we are very observant we shall notice that they are seen only at places at or near which there are various crossings or bends in the lines. The cases really cover an automatic signal apparatus, and are so placed to protect the appliance. The automatic signal is operated by the train itself as it passes over the rails, and instantly a loud bell is rung, which gives audible warning that a train is crossing the points or coming round the dangerous portion of the track. We may often hear these bells ringing when we are standing on the platform at a junction station.

WHY A PAINTER'S BRUSH HAS A HOLE IN IT.

When the painter is next at our house, if we look at some of the larger brushes he uses we shall probably notice that there is a small hole through the centre of the wood. This hole serves a very useful purpose. When a painting job is finished, the brush has to be thoroughly cleaned ready for use with paint of another colour, and the cleaning is done by means of turpentine; but if it were merely stood in a vessel containing the liquid, the bristles, owing to the weight of the brush being thrown upon them, would bend, and the tip of the brush would be curled round. This difficulty is overcome by drilling a hole in the brushes, and passing a strong wire through several of them, so that they can be suspended in the vessel of turpentine, the wire on which the brushes hang resting on the edges of the vessel.

WHY SOME SIGNALS HAVE RINGS ON THEM

If we look out when travelling on the railway, we may often see signals with a ring on the arm, as shown in the picture.



It will be noticed that these always appear at places where there are several pairs of lines, and consequently a number of signals for the guidance of the engine-driver. The signals are, as far as possible, ranged over or near the lines for which they are intended, with the result that some of the large signal-stands support many signals. In order that the drivers may make no mistake in following the correct signals, those intended for slow-line trains have rings attached to the arms, and are therefore easily distinguishable from the express signals.

WHY A COAT-SLEEVE HAS A ROW OF STITCHING

Men's and boys' coats always have a row of braid or stitching running round the sleeves just above where the buttons are placed. This gives the appearance, more or less, of a cuff, although in reality it is a sham. Many years ago, when coats were made of silk, velvet, and other delicate and costly materials, the sleeves were made wide, so that at meal-times they could be turned back to keep them clean. Later, coats were made with permanent turn-back cuffs, but, as these were rather thick and clumsy in appearance, they eventually came to be replaced by the braid or stitching on the sleeve itself, which gave the appearance of the cuff without the reality.

WHY SOME WINDOWS ARE BRICKED UP

Many of the houses that were built in the times of Queen Anne and the Georges have openings like windows, but, instead of being fitted with glass to let in the light to the house, they are bricked up, suggestive of a dungeon or a prison. This may seem a very foolish way of building a house, but there was a reason for it when the house was first put up. In those bad old days there was a tax on every window, and so it paid people to have dark houses with no proper ventilation. Many people who built houses, but could not afford to pay taxes on many windows, built the windows and had them bricked up, so that if later they could afford to pay more taxes, or the tax was removed, the bricks could be taken down and glass substituted. It was not until 1851 that the tax on windows was done away with, the much more sensible house duty which we now pay being levied in its place.

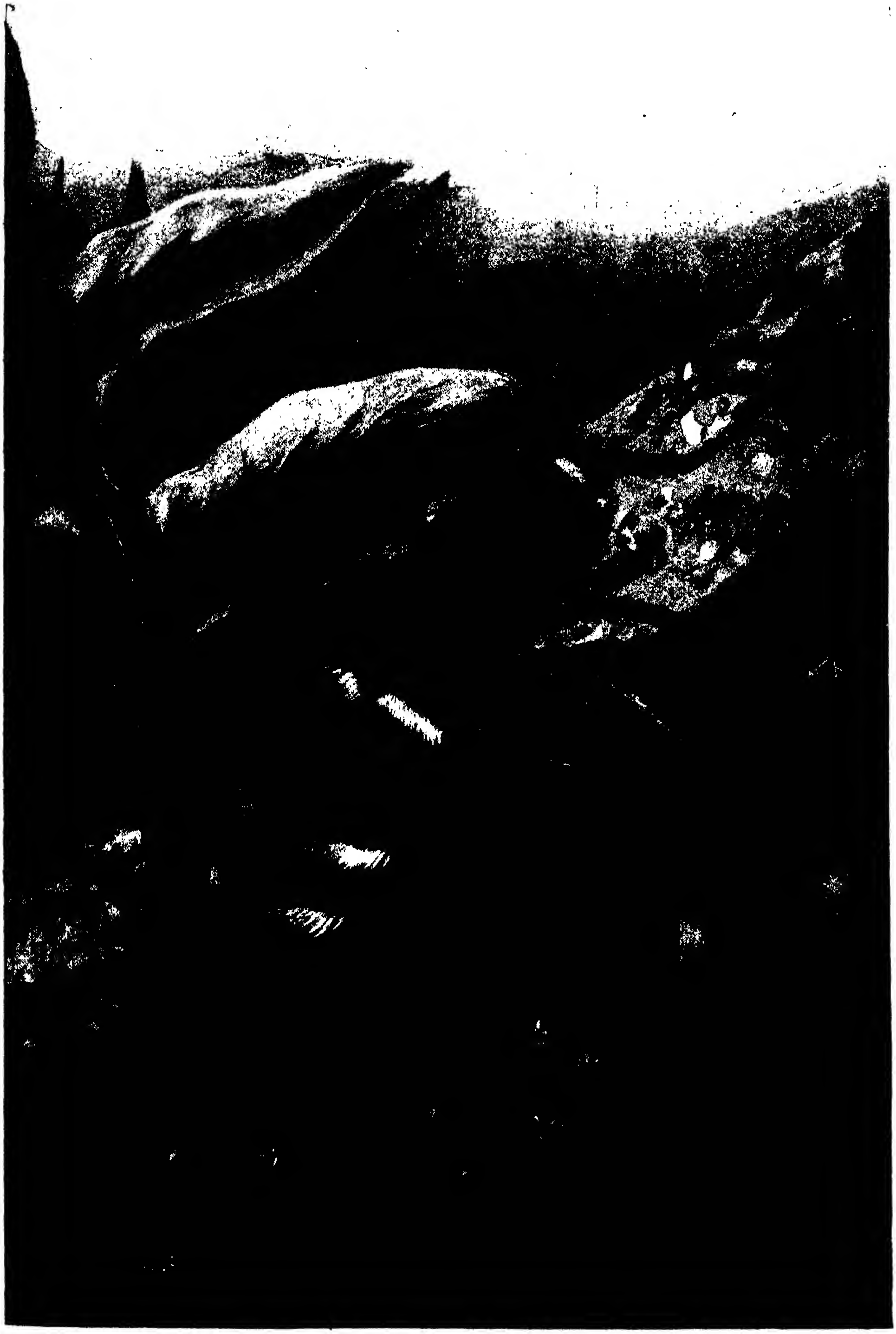
WHY SOME SOLDIERS HAVE T ON THEIR COATS

If we look carefully at the soldiers whom we see about the streets or in trains and tramcars, we shall notice that some of them, in addition to the letters and figures which denote the regiments to which they are attached, have upon their shoulder-straps the letter T. This is a mark that has been seen only during the past few years, and is a sign that distinguishes the men of the Territorials from regular soldiers. The T is, of course, the initial letter of the word Territorial. It is, undoubtedly, the simplest method that could be devised for making the necessary distinction, and it will be interesting, if the meaning of the T is new to us, to look out for any soldiers who may be coming in our direction, to see whether they are Regulars or Territorials.

WHY RAILWAY POINTS HAVE A DOUBLE RAIL

In order that trains may run from one set of rails to another, there is an arrangement known as points, worked from the signal-box. This arrangement consists of a pair of rails that can be shifted slightly to the right and left, so as to join up with other rails, and where one line runs on to another there is a V caused by the junction. We may have noticed at such junctions that the outer rails have a second length of rail placed close to them, and running for a short distance only, forming a kind of double rail. This short length is known as a safety rail, and is for the purpose of keeping the outer wheel of a train close against the rail on which it is travelling round a curve or across a point. If it were not for this the wheel might be inclined to jump away from the rail, and a serious accident might result.

A LONELY MEMBER OF THE INSECT WORLD



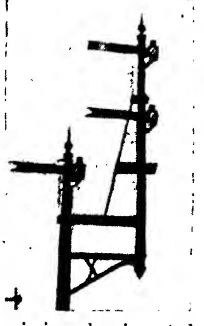
A HIGHLY MAGNIFIED PICTURE OF A SOLITARY ANT

WHY A PUTTY-KNIFE IS BLUNT

THE knife which the glazier uses for fixing the putty in position when he is putting in a pane of glass is generally blunt, and has a rounded end. If an ordinary table-knife or a penknife were used, the sharp edge would not only cut the putty as it was being pressed against the glass and window-sash, but it would probably cut the woodwork as well, spoiling it, and making it less rigid for the support of the glass. The putty-knife is also made flexible, so that it will bend as the putty is pressed down.

WHY SOME SIGNALS HAVE FORKED ENDS

IF we look at the signals on the railway, we shall notice that, while most of them have rectangular ends, there are some whose ends are forked, or have what is technically known as fish-tailed blades. These are the "distant" signals, and are placed in advance of any particular point of danger on the line. They repeat the message of the ordinary stop signal, so that when the latter is at danger the driver of the engine has early notice of the fact, and by thus getting time can reduce the speed of his train should it be travelling at express rate. A distant signal is the only signal which a train may run past when the arm is in a horizontal position. To distinguish the distant signal at night, different devices are used on different railways. On some it shows a white light instead of a red, and on others an additional lamp shows an arrow-shaped line by the side of the red or green light.



WHY A BILLIARD CUE HAS A FLAT END

THE thick end of a billiard cue always has one side flat, as though a slice had been taken off for about six inches with a sharp knife. Skill in billiards depends not only upon keenness of sight and judgment in guessing distances, but also in steadiness of hand and accuracy in striking the balls exactly in the right place. The handle end of the cue is made flat in order that the fingers may hold it in any position without the fear of its slipping round accidentally. Were the handle quite round, there would be a danger of this, and, of course, the game could not be played properly.

WHY SLATES ARE BUILT INTO THE WALL OF A HOUSE

IF we watch the building of a house, we shall probably notice that after the foundations have been put in, and what is called the damp-course erected, the builders place slates upon the brickwork, as shown in this picture. The damp-course is really a series of low brickwork bases on which the ground floor of the house will stand, and the bricks are built up to a height of a foot or a little more, when the layer of slates is cemented into position. The lower floors are thus laid on brick piers, or walls, so that there may be a current of air circulating under the house and keeping the floors dry. The slates are used because they are damp-proof, and prevent the moisture rising through the brickwork. Sometimes a preparation of bitumen is used instead of slates, but this is not so effective.

WHY A PILLARBOX SLOT SLANTS UPWARD

EVERY boy and girl knows that the slot, or opening, of a pillarbox slants upward, because this makes it difficult for a very little child to post a letter. If we can only just reach the opening, we find that, though we push the letter inside, it slips out again, because of the slant in the slot. To allow the letter to fall inside the pillarbox, we have not only to push it through the opening, but so far through that it will go right over the bevel, or slanting entrance, and fall down among the other letters. This curious arrangement of the opening may seem foolish, but there is a very good reason for it. In wet weather the rain beats all round the pillarbox, and if it were not for the entrance passage slanting upward the water would go into the box and soak the letters. Another purpose which the upward slant serves is to make it more difficult for thieves to get letters out of the box.

WHY A PLAIN GOLD RING IS USED AT WEDDINGS

THERE are many people who would not consider that they were married at all unless a plain gold ring of the recognised type were used at their wedding. But, as a matter of fact, such a ring is not necessary, and within recent years some very strange substitutes have been used. In one case the ring-like handle of a key was used, and in another a leather ring cut from the finger of a kid glove served the purpose the gold ring had served. The reason for using the plain gold ring is custom. The ring is used as a symbol that the husband endows the wife with his wealth.

WHY CHILDREN BUILD A GROTTO

IN the side streets of London and other large cities, children build grottoes of oyster-shells, put a lighted candle inside, and, going up to all the strangers who pass, hold out a shell for a gift of money, crying as they do so, "Please remember the grotto!" This is a relic of an old custom. It was formerly observed round about July 25, which is St. James's Day. Large numbers of people used to make pilgrimages to a famous shrine of St. James at Compostella, in Spain, and carried in their hats a scallop-shell as a symbol of the saint. Taking advantage of this popular devotion, beggars used to build little grottoes of scallop or oyster shells, light them with a candle, and beg alms from the passers-by, who were asked in this way to show their regard for the saint.

WHY VIENNA ROLLS ARE CRESCENT-SHAPED

WE may have often wondered why Vienna rolls are made in the shape of a horseshoe or crescent, and there is an interesting story told in history to account for this. When Solyman the Magnificent was besieging Vienna in 1529, he decided, on the advice of the Turkish engineers, to burrow his way into the city. So on the night of September 27, when the people of Vienna supposed the enemy to be sleeping, the Turks began tunnelling under the walls of the besieged city. Some Viennese bakers, however, working in a cellar near the walls, making bread for the garrison, heard the noise, and warned the Austrian guards, who discovered the strategy and drove off the Turks, so saving the city. To celebrate their discovery the bakers made their bread in the form of crescents, and their successors have continued doing so to this day.

WHY DOORS OPEN INWARDS

IF we take notice we shall see that all doors, whether they be the doors of rooms or street doors, open inwards—that is, into the room or house. This is, of course, a matter of convenience. If street doors, for instance, opened outwards, a person running along the street just as the door of a house were opening outwards would run against it, and possibly be knocked down. Not only so, but if doors opened in this way a great deal of the space on the pavement would be occupied, and in busy thoroughfares there would be crowding and delay. Hence the owner or builder of a house is compelled to have his door open inwards. The same principle is applied to room doors.

WHY A TRAIN-RAIL IS HELD BY WOODEN WEDGES

THE metals of a railway track are held in position by iron sockets fastened to wooden sleepers, which in their turn are held fast by the gravel of the permanent way. The metal sockets are called chairs, and it will be seen that the rail does not fit tightly into the chair, but is held fast by a wooden wedge. If we watch the platelayers repairing the line at a station, we shall see that they drive in these wedges with blows from a sledge-hammer. The chair is made too large for the rail, in order to allow for expanding in hot weather, the wooden wedge having the necessary "give" to allow for this.

WHY A PIPE HAS A RIM ROUND THE STEM

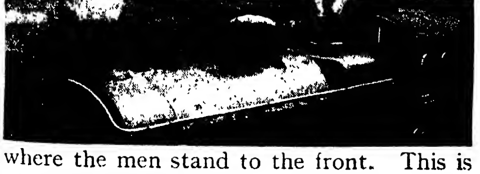
EVERY tobacco pipe, even those that are made of clay, and many cigar and cigarette holders, have a small raised rim running round the edge of the mouthpiece. This is to enable the smoker to hold the pipe in his mouth. If there were no notch and the mouthpiece were quite smooth, the least knock or jerk, or even the weight of the bowl, would cause the pipe to slip from between the lips, with the result that it might fall to the ground and get broken. The rim, however, catches against the clenched teeth of the smoker, and so the pipe is held tight and cannot slip away. Although most cigar and cigarette holders have the rim, it is not so necessary with them, as their weight is much less than that of a pipe, and there is not so great a tendency to fall from the lips.

WHY COINS HAVE THICK EDGES

WE may not have noticed that all our coins, from the farthing to the sovereign, have thickened edges. We can see this best in the newer coins, for as they are used the extra thickness—that is, the raised edge all round on either side—gets worn down, and when such is the case we notice also that the design—the King's head and the reverse side—are also worn. This explains the reason for the raised edge, which is to protect the design from getting rubbed away as the coins knock one against another while in general use. This thickening of the edge may seem a small thing, but were there no thickening the design would disappear in probably a tenth of the time that it takes at present.

WHY A LOCOMOTIVE HAS A HAND-RAIL ROUND IT

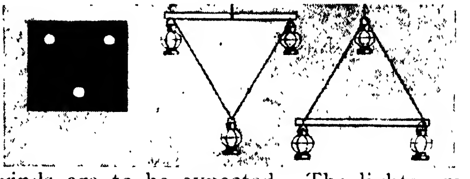
IF we look at a locomotive carefully, we shall see that there is a handrail running along it on either side from the cab



where the men stand to the front. This is very necessary for the protection of the drivers, who often have to go round the engine while it is in motion to oil or examine it, and only by holding firmly to the rail is it possible to keep on the engine when it is moving quickly. Only men of experience can do this, for it needs a vast amount of nerve to move round the engine when it is rushing along at a great rate.

WHY THREE LIGHTS ARE SHOWN AT A SIGNAL STATION

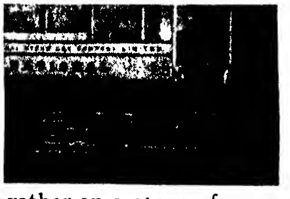
AT various ports round the British coasts, and at Lloyd's signal stations, we may often see at night three lights, arranged as in the first diagram. At other times the lights are reversed, one being at the top and two at the bottom. These are storm signals, and are put up to warn mariners of the direction from which gales or strong



winds are to be expected. The lights are really lanterns hung on a triangular frame, as shown in the second and third diagram here. They take the place of the storm cones which are raised in daylight. These cones would not be seen at night, and so the shape of a cone is indicated by the three lights. When the two lights are at the top and one underneath, gales are probable from the south, and when this order is reversed, and the single light is on top, the gales are expected from the north.

WHY A MOTOR-BUS HAS SIDE-GUARDS

PRACTICALLY all the motor-buses seen in the streets of London are now fitted with an apparatus on each side between the front and back wheels of the vehicle. The appliance consists of a series of stout wooden



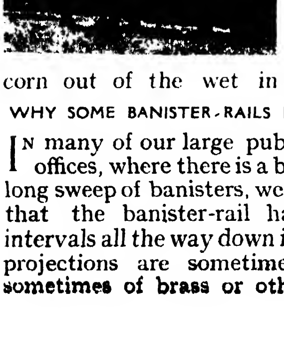
slats held firmly together on a strong frame, and they are there to prevent any unfortunate person who happens to be knocked down by the omnibus or to fall in its way from being run over by the back wheels. The apparatus is really a kind of "cow-catcher" adapted to a modern motor vehicle. These guards are certainly of some use, although they do not meet the case of persons falling before the front wheels. So far, no one has been able to invent a guard which will protect anyone falling in front of a motor-bus.

WHY A FRENCH NAIL HAS GROOVES

The smooth, bright nails used by carpenters, and known as French nails, have a series of grooves or lines just below the head. These are to enable the nail to hold firmly when it is driven into the wood. Were it quite smooth from the point right up to the head it would go into the timber in the same way as it does now, and might grip sufficiently well at first, but any friction, caused by wear and tear or the regular shaking of the timber, would tend to work it loose, and the nail, being smooth right round, would tend to spring. The effect of the grooves or lines is very much the same as in the case of a screw, though, of course, being much less pronounced, and not forming a continuous line like the ridge round the screw, they do not grip so well.

WHY CORN-STACKS OFTEN STAND ON LEGS

It is by no means uncommon for stacks of corn to be seen standing on legs like the one shown in the picture, and even where the legs cannot be seen it is quite usual to raise the stack slightly from the ground on bricks or beams. This is to prevent rats making themselves comfortable in the bottom of the stack, and eating the corn unseen by the farmer and his workers. A score of rats getting into a stack built on the ground might do hundreds of pounds' worth of damage in a very short time, and this would only be discovered when the stack was broken up for threshing. The legs also raise the corn out of the wet in a rainy season.



WHY SOME BANISTER-RAILS HAVE PROJECTIONS

In many of our large public buildings and offices, where there is a big staircase with a long sweep of banisters, we shall often notice that the banister-rail has projections at intervals all the way down its length. These projections are sometimes of wood and sometimes of brass or other metal. They are usually more or less ornamental, but it is not for purposes of adornment that they are placed in position on the rail. Where these long sweeps of banisters occur there appears to be a great temptation to foolish boys to lean over them and slide from top to bottom. This is not only dangerous to the boy, who may easily overbalance and fall right over, but it is also dangerous to people coming up the stairs. The projections are therefore placed all down the rail to make it impossible for anyone to slide down it.

WHY VIOLINISTS RESIN THEIR BOW-STRINGS

It is pretty generally known that violinists rub a piece of resin up and down the strings of their bows from time to time. This is in order to make the bow-string do its work as it passes over the strings of the instrument. If the bow-string were left untouched it would simply slide smoothly up and down on the violin strings, and little or no sound would be produced. The music of a violin is caused by the vibrations of the strings as they are played upon by the bow, and these vibrations can only be produced in perfection when the bow-string has been sufficiently roughened by the adhering resin to grip the strings of the violin. The bow is horsehair, and the strings are catgut.

WHY AN ELECTRIC GLOBE HAS A TAIL

The ordinary electric globe used in our houses ends in a small point, or spike, of glass, which sometimes is so elongated as almost to appear like a tail. This has nothing whatever to do with the purpose for which the globe is used, as is sometimes supposed, but is really the finish-up of the globe when it is made by the glass-blower. Not only so, but the little tail adds strength to the globe, and prevents it being broken without rough usage.

WHY A BALL IS RAISED AT SOME SEASIDE RESORTS

At some of the well-known seaside resorts round the English coast, such as Scarborough, it will be noticed that a ball is raised to the top of a prominent flag-mast at certain times of the day, and is allowed to remain there for some hours. The ball does not appear at the same time each day, but gets a little later every day. Its appearance is a sign to the captains or pilots of vessels wishing to come into the port that there is sufficient water for them to navigate their boats, while if the ball is down they know that they will be unable to make their way in. In the picture it is down, and so ships are to understand that they must wait. The method of indicating the state of the tide is not exactly the same at all places, and, of course, where a harbour is navigable at low tide as well as at high tide it is not necessary to have any signal at all.

WHY SOME SIGNALS HAVE A SMALL ROUND DISC

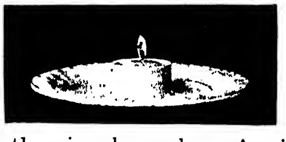
On some railways a number of round disc attachments, similar to that shown in the photograph, may be noticed on the signal-posts. These are warning signals of the Sykes Interlocking Signal Company, and are used in a special system of signalling known as the "section clear but station blocked" rule. By the movement of the indicator inside the disc, which is operated by electricity and is controlled from the next cabin, a train is allowed forward when the line is occupied beyond the home signal at the next cabin, and when "line clear" cannot be given in the usual way. These electrical warning signals are used chiefly at those places where it is of special importance to move trains quickly and save time.

WHY WIRE NETTING IS PUT ROUND TREE-TRUNKS

In orchards, gardens, and other places in the country, we often see a piece of galvanised wire netting fastened round the trees close up to the trunk. This is to protect the trees against the hares and rabbits which come out at night, and often by day, and gnaw away the bark, doing serious damage to the fruit and other trees, which would dwarf their growth, interfere with their vitality and fruitfulness, and possibly kill them. The wire guard, if the mesh be fairly fine, is an adequate protection, and has been found by farmers and others to be the cheapest and most effectual means of combating the depredations of the little animals. In towns, too, the trees by the sides of the road are protected with wire netting, as shown in the picture, in order that the trunks may not be damaged by boys and others.

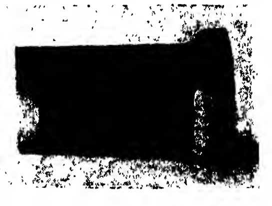
WHY NIGHT-LIGHTS ARE BURNED IN WATER

The directions printed on a box of night-lights always advise that the lights should be stood in a saucer containing a little water. Some people think that the water improves the brilliancy of the light. Such an idea is, of course, quite without foundation. The saucer of water is used purely for safety's sake. A night-light has very little possibility of danger in it at the worst, but it is certainly safer to let it be like an island surrounded by water.



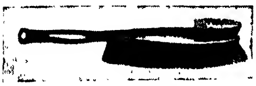
WHY DRAIN-PIPES HAVE A BLACK LINE

We may have noticed that where workmen are laying a drain the pipes sometimes have a black line round them, drawn either with paint or tar. The reason for this is to show that the pipes are really of second quality, and the custom is one that has only grown up in recent times. Earthenware drain-pipes are so much alike in appearance that it is not always easy to tell what their quality is, and this practice is now followed by builders generally, as being a very simple means of indicating the quality of second-grade pipes. The black line is drawn round each individual section of pipe, as shown here.



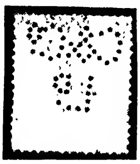
WHY SOME CLOTHES BRUSHES HAVE BRISTLES ON BOTH SIDES

Many clothes brushes have, in addition to the regular set of bristles, a small batch of much stiffer bristles on the other side of the woodwork and near the tip. The reason for this is that the brush becomes not only an ordinary clothes brush for removing dust from our garments, but also a mud brush. The extra stiff bristles on the upper side enable us to remove splashes of mud that have dried hard on our clothes, and need something more than the usual brush to get them off. A brush with this set of stiff bristles on the upper side is said to have a splash back.



WHY SOME POSTAGE STAMPS ARE PERFORATED

The postage stamps attached to many business letters have a number of perforated holes, which, if looked at closely, will be seen to form letters of the alphabet, as, for instance, A. B. or C. & C., Ltd. These letters are the initials of the firm sending the letter, and the stamps are thus perforated to prevent any dishonest person in the office stealing them and selling them. No post-office will buy and no firm will receive in payment for goods any stamps which are perforated, and so petty robbery of stamps is prevented. The perforation is done with a punch in the office, or the stamps may be bought from certain firms who supply them perforated with any initials or letters. The back of a perforated stamp is shown.

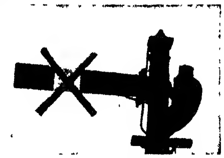


WHY SOME GATES WORK BETWEEN TWO FENCES

It is very usual for a gate that is set up at some point on a footpath where the public have a right of way to work backwards and forwards between two fences. Such gates are almost invariably found at level crossings over railways, and there they serve a double purpose. The play of the gate gives plenty of room for a man or woman or child to get through quite easily, but an animal, even one so small as a sheep or pig, would find it impossible to negotiate the gate. The second use of such gates at level crossings is that they make it impossible for a person to rush thoughtlessly from the path across the line without waiting to see if the line is clear. The negotiation of the gate compels one to stop for a moment, during which an approaching train would be heard or seen.

WHY SOME SIGNALS HAVE A CROSS

We sometimes see on a signal gantry—that is, on one of those large bridges covered with signals that stand near important junctions or great termini—one or two signals with crosses on their arms. These are simply to indicate to the engine-drivers that such signals are, for some reason or other, temporarily out of use, and are to be disregarded. It is, of course, important that a driver should be able to know instantly that a signal out of use or out of order is to be disregarded: it would be very serious if a signal that was out of use were to be treated as if it were set for or against. The cross towards the end of the arm has, by experience, proved to be thoroughly effective for the purpose. It is easily seen at a glance from a distance, and cannot possibly be mistaken for any other sign or mark used in connection with railway signals.

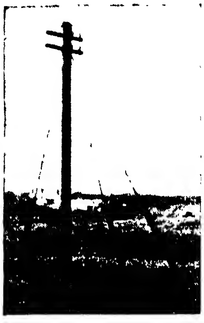


WHY A TRAWLER RAISES A ROUND BASKET

We may have seen one of the trawling vessels, of which there are so many in the North Sea, with a round basket, similar to that shown in the picture, raised to the masthead. This is an indication to other vessels that may be in the neighbourhood that she is actually trawling, and they then make way for her. It is clear that without some such warning there would be not only serious interference with the trawling operations, but much destruction or loss of valuable nets, for another vessel passing immediately across a ship that was trawling would probably foul the ropes that were dragging the nets, and cut them. The size of the trawl varies according to the size of the vessel using it, but the nets are very large. The round basket is used for hoisting to the masthead in preference to an object of some other material, because it stands the weather very well, and the give of the basket-work prevents it being easily damaged in a gale.

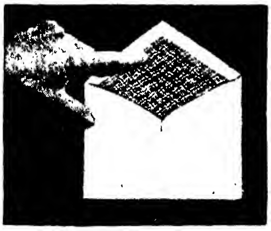
WHY TELEGRAPH POLE SUPPORTS HAVE PALINGS

TELEGRAPH poles that have an unusual strain upon them are often supported by a series of two or three wires reaching from the top of the poles to the ground, as shown in the picture. But for about eight or nine feet up these wires from the ground there is often placed a length of stout wood like a paling. These palings lend no support to the wires to which they are affixed, for their bases are not firmly buried in the ground. They are not intended for supports, but are simply placed in position to make the wires visible to passers-by, and, where the telegraph pole is in a field, to the cows and horses. Were it not for the thick wooden palings, the wires would be quite invisible in dusk or darkness, and anyone running into them might be injured.



WHY SOME ENVELOPES HAVE DESIGNS INSIDE

THE thin envelopes used for foreign correspondence have a peculiarity which distinguishes them from ordinary envelopes. Whatever colour they may be outside, the inside is always either a dark colour—grey or blue, for example—or instead of the colour there is a closely printed geometrical design, usually with wavy lines. There is a very good reason for this peculiarity. The paper, being so thin, is more or less transparent, and were the envelope left plain inside and out it would be an easy matter for anyone to read through the envelope that part of the letter which was exposed. By printing a confused and wavy design on one side of the paper, or by covering it with a dark colour, the envelope is rendered practically opaque, and the privacy of the correspondence is preserved.

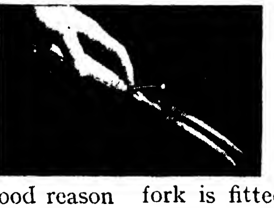


WHY WINDOWS HAVE GAUZE COVERINGS

IT is not uncommon to see in the country certain windows of the farmhouses and other buildings covered with a gauze. Sometimes this is the permanent and only covering, while at other times the window may be double, having the usual glass sash and also another sash with the gauze. The windows so arranged are usually those of dairy apartments or larders, and the idea is to give adequate ventilation without allowing the insects, wasps, flies, and so on, to enter and contaminate the food with poisonous microbes. The idea is such a good one that it is being followed largely in town larders. Some of the large jam manufacturers in the country, too, have all the doors and windows of their factories fitted in this way with gauze coverings, so that the buildings may be rendered wasp-proof.

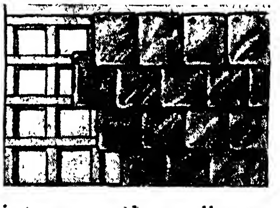
WHY A CARVING-FORK HAS ONLY TWO PRONGS

WE need a dinner-fork not merely to hold the food while we are cutting it, but also to convey that food to our mouth. In the case of the carving-fork, however, its principal use is to hold the joint while we cut the slices of meat off, and in order that the passage of the knife may be impeded as little as possible, and the meat may not be disfigured with too many fork-holes, the carving-fork is fitted with two prongs only instead of the familiar three.



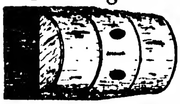
HOW THE SLATES ARE FASTENED ON A ROOF

THERE is a method of fixing tiles on a roof so that the inside of the house is properly protected and the rain prevented from coming into the rooms. The slates overlap, both on the side and at the bottom, and in this way, whatever water may be running down a slanting roof, it is carried by the overlap from tile to tile until it falls off the eaves into the gutter that runs the length of the house, or drops upon the ground. The bottom row of slates or tiles juts over the walls, so that the water will not drip down them.



THE HOLES IN THE BROOM

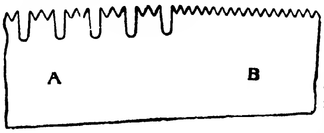
The large brooms used by roadsweepers



and others have two holes, so that, when worn, the handle may be changed into the other hole, thus giving both sides of the bristles an equal amount of wear.

HOW THE SAW IS STARTED

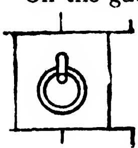
The large saws seen in tool-dealers' windows, and used for cutting up logs and felled trees, have a large number of teeth like those shown at A in the picture, and a few smaller ones like those at B. The reason



for this is so that the saw may be gradually started into the wood with the fine teeth, and then the larger ones take to the work more easily. It would be very difficult to begin with the large teeth, because they would hitch and waste time unnecessarily.

TO TIE HORSES TO

On the gateposts outside country houses



are generally seen one or two iron rings, as shown in the picture. To these rings horses are tied while the tradesman or visitor goes up the pathway to the house. If it were not for this the horse would stray away and become a danger to other traffic.

FIRE-PLUG

The letters F.P., or sometimes F.H., with

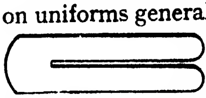
figures marking a distance, indicate that a fire-plug or hydrant will be found in the path or road that distance from the plate. This enables the firemen to find the nearest hydrant immediately.

TO PREVENT BIRDS NESTING

The wire guard on top of the tall iron air-pipes that stand up above the roofs of buildings is to prevent birds from building a nest on the top of the pipe, or from dropping sticks down, which would interfere with the drainage system.

A BUTTON-STICK

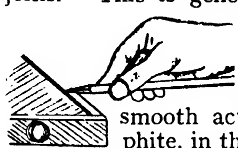
Those who have to polish brass buttons on uniforms generally make use of a button-



stick, a piece of brass with a slot cut in it. This is slipped under the button, so that it may be cleaned without soiling the cloth around it.

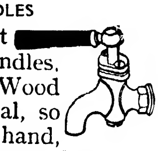
TO MAKE A DRAWER SLIDE EASILY

Nothing is more annoying than to have a drawer which will not slide freely, but sticks, and goes in and out by a series of jerks. This is generally due to a slight



swelling of the wood and to roughnesses on the surface. A good method of obtaining smooth action is to apply graphite, in the form of an ordinary lead pencil rubbed along the sliding surfaces. This fills up the pores of the wood, and removes the roughness, giving a perfectly free action. The same remedy may be applied to stiff camera-slides, pencil-box lids, and so on.

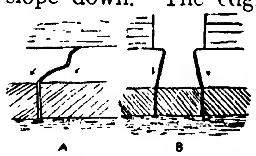
WOODEN TAP-HANDLES



Taps which are used for hot water often have wooden handles, as shown in the picture. Wood does not get as hot as metal, so that it is comfortable to the hand, even though the tap may be very hot.

HOW KERB-STONES ARE LOCKED

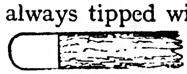
When a path is made up there is often a strong pressure of earth tending to force the kerb out of place, especially if the path slope down. The edging stones are then



fitted together as shown in picture A, being cut V-shaped, so that they lock into each other and cannot be forced outwards. Sometimes a long stone reaches partly across the path and is cut in dovetail fashion, as picture B shows, to drop in between the tapered ends of the two kerbstones and hold them from shifting gradually outwards into the roadway.

TO SAVE WEARING THE SHAFTS

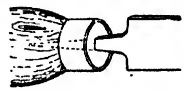
The shafts of carts and carriages are always tipped with iron at the ends. This



is to prevent the wood being rubbed away when the horse is taken out, and the ends of the shafts drop on to the ground and slide along.

TO PREVENT A HANDLE SPLITTING

Tool-handles, such as those for chisels, files, bradawls, and so on, have an iron or



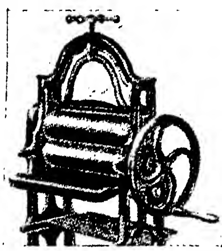
brass ring, or "ferrule," at the end where the tail or tang of the chisel enters. This is not for the sake of appearance, but is used in order to prevent the wood from splitting open by the driving in of the tang.

WHY SOME GATES HAVE ONLY TWO BARS

We may sometimes see a gate having only two horizontal bars with a considerable space underneath. This is for the convenience of the farmer in picking out particular sheep. When he has a number of sheep in a field and wants certain ones, he gets his dog to drive them up to the gate, and as they come forward he selects the animals required, and by pressing their heads down slightly he can push them under the gate. If he had an ordinary gate which had to be opened for the passage of the sheep, many would rush through the opening, but by having a gate where the animals must stoop they are kept in, for they will not pass under without being pushed.

WHY A MANGLE IS UNSCREWED AFTER USE

It is usual after a mangle has been used to slacken the screw on top. This is done for two reasons. In the first place, the spring that presses the top roller on to the under one is loosened. If it were kept tight, it would very soon lose its tension, and the rollers would not give to clothes of varying thicknesses passing through. The screw is loosened, also, to prevent two flat surfaces forming where the rollers touch, as would certainly happen if the machine were left untouched for any length of time with the top screw turned tightly. The wood of the rollers, which becomes softer after wringing, would soon be spoilt in that case.



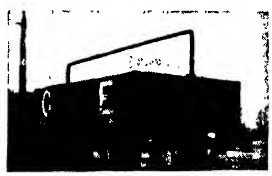
WHY OUTDOOR TAPS ARE COVERED WITH STRAW

In the winter-time we may often see water taps and pipes that are out in the open air covered with straw. This is to keep the frost away from the pipe, and thus prevent the water inside turning into ice and splitting the pipe, as it will do on account of the fact that water, when it freezes, swells a little. The straw is a very useful covering. It is generally accessible, and, being a poor conductor of heat, retains whatever heat there may be in the pipe and the water, and so prevents freezing.

Other substances, such as woollen rags, are also used for the purpose, and their operation is generally successful; but, while these things may not be very easy to get when they are wanted, straw is so common that it is always available.

WHY SOME RAILWAY TRUCKS HAVE AN IRON BAR

It will be noticed that a good many of the trucks that make up our luggage trains have a large iron bar running the whole length of a truck, as seen in this picture, and the bar is movable, so that it can be raised, with the supports perpendicular and the bar itself resting over the whole length of the middle of the truck. This is a provision that enables a truck-load of goods to be preserved from rain and weather. After the truck is loaded the bar is raised and a large tarpaulin is pulled over it, the bar supporting the middle of the tarpaulin, tent fashion. The sides can then be allowed to fall down over the edges of the truck. The sloping of the covering enables the water to run off instead of collecting in pools, as it would do if the tarpaulin were flat.



WHY AN ENGINE HAS HANGING BARS IN FRONT

Every railway engine that we see has, hanging down in front of it, before each of the two wheels, a slightly curved metal bar, which almost touches the line. These bars are for the purpose of clearing the rails of any obstacle that might be lying upon them. Many a time an obstacle that has been placed on the line by some malicious or thoughtless person, or some object that has fallen there from a bridge or bank, has been turned to right or left by the metal guard.

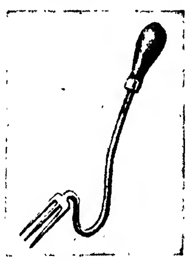
In America, where the huge lengths of track are not protected by hedges, and cows and other creatures often stroll on the line, the engines have a large barred attachment in front of them, called a cow-catcher, and this will clear the line of very formidable objects, and so avert what might prove a serious accident.

WHY A BRICK WALL IS SOMETIMES CHIPPED

We may often see a workman chipping the bricks of the wall of a building, using a sharp tool something like a chisel, which he knocks with a hammer. The little dents are made all over the face of the wall, and if we do not know why the chipping is done we may think the man is simply disfiguring the brickwork. As a matter of fact, the operation is preliminary to plastering the wall. If no little holes were chipped in the bricks there would be no hold for the plaster, and after it had dried it would gradually fall off in pieces. With tiny holes to go into, the plaster gets a firm hold on the wall.

WHY A GARDEN WEEDER IS CURVED

Modern garden-weeding instruments usually have a sharp bend immediately before the prongs, and this renders the tool much more serviceable than if the iron were straight from the handle to the prongs. Many of our common weeds have very strong roots, which work their way deeply into the soil, and hold tenaciously, so that a great wrench is needed to get them out. The bend in the weeding instrument enables the gardener to get a more powerful leverage by increasing the size of the fulcrum, a tool of this kind being a very simple illustration of a lever of the first class. Being rounded where it rests on the ground, the fulcrum does not sink deeply into the earth.



WHY NOTICES ARE HUNG AT CHURCH DOORS

The Government have the right to affix notices about elections, taxes, juries, rates, and so on, to the doors of parish churches and other buildings licensed as places of worship. This right is a very old one, dating back to the time when everybody was supposed to attend public worship and the parish church was the centre of the life of the community. The porch or door of the church was therefore a place of regular resort, and any notice placed there was sure to be seen by the largest possible number of parishioners. The authorities may place the notices actually on the door itself, but where a suitable notice-board is provided in a conspicuous spot near the entrance to the church, they usually affix the announcements to that, and thus avoid the disfigurement of the door.

WHY SOME POSTAL PARCELS ARE MARKED "COACH ROAD-BORNE"

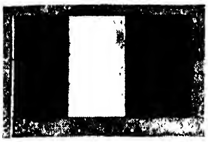
The words "Coach Road-Borne," surrounded by a black line, are often seen stamped on a parcel that has been delivered by the postman. It is a comparatively recent mark, and while nearly all the parcels that are received by post in certain places have the mark, there are other places where it is never seen on the parcels that are delivered. The words indicate one of the changes wrought in modern life, one that has resulted from the introduction of the motor-car. Of recent years the Post Office has acquired a fleet of motor mail vans, and between many towns, as between London and large centres in the eastern and southern counties, the mail, or a part of it, instead of being sent by train, is now carried by these powerful motor-vans, which usually travel at night. Parcels so carried have the method of transport stamped on them.

WHY A MASON'S HAND-CART HAS SOLID WHEELS

Those who have watched the men at work in a mason's yard will probably have noticed that the small, flat hand-trucks on which the slabs of stone are moved about, instead of having ordinary wheels of iron, are fitted with solid wooden wheels, as shown in this picture. The stones being very heavy, exceptionally strong wheels would be needed if these were made with spokes in the usual way, and a pair of strong, massive metal wheels means much weight, which, added to the weight of the stone, would render the truck unmanageable. To get over the difficulty wood is used, and in order that the wheels may be able to bear the strain they are made solid, as shown.

WHY THE FRENCH FLAG HAS UNEQUAL STRIPS

It is not generally known that the three strips of colour that make up the French national flag are not equal in width. When the tricolour was first authorised, in 1792, the positions and proportions of the three colours were not stated, and such a variety of flags was seen that two years later the National Assembly declared that the national standard should be formed of "the three national colours in equal bands placed vertically, the hoist being blue, the middle white, and the fly red." For years the flag was made in this way; but though the bands were equal, they never looked equal owing to an optical illusion, the blue appearing wider than the white, and the white wider than the red. At last, after many experiments, it was officially decided that in every hundred parts blue should be 30, white 33, and red 37. This proportion gives the effect of equality in width.

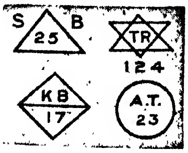


WHY THE WELSH FUSILIERS WEAR A FLASH

As a result of the movements and training of troops recently, many people have noticed for the first time the "flash," or bunch of black ribbons, that hang from the back of the collar of the officers of the Welsh Fusiliers. This has been more conspicuous than usual because it has shown up by way of contrast on the khaki uniform. It is a survival from the days of bag wigs, when not only did the wigs have a great bow of black ribbon at the back, but a similar bunch of ribbons was sewn to the back of the coat-collar to protect the garment from the pomatum and powder with which the wig was dressed.

WHY PACKING CASES ARE MARKED WITH TRIANGLES

Packing cases containing goods for another country, or those that have brought goods to this country from abroad, usually bear upon their sides, stencilled in black, a triangle or other geometrical outline, with figures and letters. These distinctive marks are placed upon the separate packages belonging to one consignment in order that the cases may be easily identified and kept together for storage or delivery. All the packages bearing the same mark can be seen at a glance. The outlines used are generally triangles, double triangles, diamonds, hearts, or circles, and they measure from fifteen to eighteen inches each way. The letters are usually the initials of the people to whom the goods are shipped, and the figures give the order number.

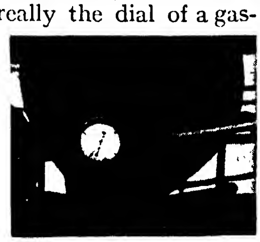


WHY SOME BRIDGES HAVE RAILINGS ON THE PATHS

We may often see in market towns in agricultural districts bridges with railings dividing the pavements or footpaths from the roadway, and at the entrance to the footpaths at each end of such bridges we frequently find a post in the middle of the pavement. It will be found that bridges having railings and posts as described are always situated near cattle-markets, and the rails are for the protection of foot-passengers as they cross the bridge. Cattle are very liable to take fright in narrow roadways, such as the bridges over railways and rivers, and if they started running wildly about the paths there might be serious accidents to foot-passengers, who on the bridge would find no shelter in which to take refuge. The railings are therefore erected so that the cattle cannot run on to the pavement, but are confined to the roadway. The post in the middle of the paths at the entrance to the bridge prevents the cattle finding an entrance to the path should they begin running about wildly as they enter the bridge.

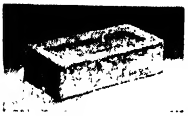
WHY A RAILWAY CARRIAGE HAS A DIAL BELOW

We have no doubt noticed that most passenger carriages on the railway have a little dial something like a clock-face down beneath the step by the wheels. A good many people think this is something to do with the brakes of the train, but such is not the case. It is really the dial of a gas-meter, which indicates how much gas there is left in the cylinders, so that the officials may know when to recharge them. With the extended use of electricity for lighting carriages, the gas-meter dial is seen less often than it used to be; but where gas is used it is, of course, very necessary.



WHY A BRICK'S SURFACE IS HOLLOWED OUT

We may have noticed that the bricks with which houses are built have a place hollowed out on their surface. The hollow is not very deep, but it serves a useful purpose, as will be seen if we stand watching the bricklayer erecting a wall. Taking the brick in his left hand, he places a lump of mortar on the top of the wall so far as it is built up, smooths it across till the surface is level, and then places the brick in position. By having the bricks slightly hollowed out on one side for the reception of the mortar, the wall is made stronger and firmer, for the individual bricks are cemented together into a whole. When the mortar in the hollow is dry it really becomes a part of the brick, and, the next and succeeding bricks being similarly arranged, the whole series is firmly connected.



WHY SOME GATE-POSTS HAVE GRANITE BLOCKS

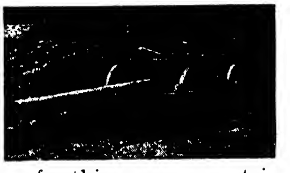
It is a very common sight to see fixed against the bottoms of the pillars that carry the large wooden gates of a country mansion stout blocks of granite, as shown in the picture on this page. Granite is the hardest of all the serviceable stones, and the blocks are placed in the position shown for the protection of the pillars and gates. As a carriage or other vehicle turns sharply round to drive into the grounds it is very liable to have its wheels graze the pillar, and so these granite blocks are fixed just where the friction is most likely to occur. Being so hard, they are not affected by the contact, and the pillars and wooden gates are saved from possible injury.

WHY BLACKSMITHS WET COAL BEFORE USING IT

A blacksmith usually wets the coal which he uses for his forge before placing it on the fire, and by this means he is able to get more heat for the heating of his metal. The coal which he uses is very small, and if it were used quite dry it would get into a red glow very quickly, and much heat would be given off into the air that is needed for the blacksmith's work. By damping the coal before using it, or by wetting the top after a fresh supply has been put on the fire, the coal cakes, a layer is formed over the fire, and the heat is imprisoned for use. Not only so, but the consumption of fuel required is less than if dry coal were used. The housewife practises the same useful idea when she places damp coal-dust on her fire to keep it in while she goes out.

WHY A WOOD CART HAS SLIDING WHEELS

Those curious vehicles consisting of a long pole and two sets of wheels, used for moving the trunks of trees, have a peculiarity that is unique and that many people have not noticed. The back wheels with their carrier slide along the pole so that they can be brought nearer to the front wheels with the end of the pole sticking far out at the back, or they can be moved almost to the extremity of the pole. The reason for this arrangement is that the cart may be adapted as need arises for long or short trunks. By moving the wheels to and fro, it is possible to distribute the weight of the load on the wheels to the best possible advantage.



WHY A COAL-STACK HAS A WHITE LINE ROUND IT

At some of the large depots of our principal railway companies we often see a huge stack of coal piled up by the side of the line. When there is any danger of a miners' strike, or any likelihood of a big advance in price, the companies stock up, and the store piled by the track is often worth a very large sum of money. Unless some precaution was taken there would be a good deal of petty pilfering of this valuable coal, and in order to prevent this it is usual to put right round the top of the stack a broad whitewashed line. By this means, if any of the coal were to be stolen, the white line would be broken, and the theft would at once be detected. Any coal taken from the great stack must, of course, be removed from the top—it could not be taken from the under part—so that the line of white round the stack is as good as a detective, so far as indicating when there has been a theft. When a layer of the coal is taken away for legitimate purposes by authorised persons, the white line is often painted on again at a lower level.

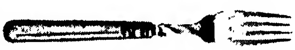
WHY PUBLIC LAND IS SOMETIMES ENCLOSED

When in the country you may have noticed, perhaps, near the junction ot crossroads, a piece of enclosed land which

seems to serve no useful purpose. This is the parish pound, set apart by law, in which stray or trespassing cattle, or distrained cattle or goods, are left until redeemed. Carlyle has this reference to the pound, interesting at the present time: "We are not an Observation Army rotting here in the parish pound any longer, but an Allied Army—intending to strike for ourselves, and get out of the pound straightway!"

WHY A FISH FORK HAS FLAT PRONGS

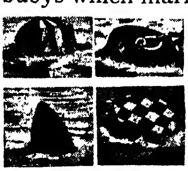
The forks which we use for fish are different in form from other forks, the prongs being wider and flatter individually, and the whole fork being also flatter. This is simply an adaptation of the ordinary fork to a special use, and



the modified shape is simply for the convenience of the user. Fish being soft, and less cohesive than meat, vegetables, pastry, and so on, could not be easily manœuvred by the ordinary-shaped fork, and so by flattening and widening the prongs the fish is able to be carried much more readily from the plate to the mouth. Fish forks are also made much smaller and lighter than dinner forks, but this is merely a case of paying some attention to the fitness of things, fish being a lighter dish than meat.

WHY BUOYS ARE OF DIFFERENT SHAPES

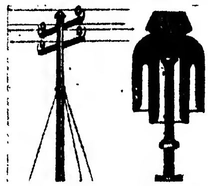
Those who have sailed or steamed round our coasts must have noticed that the buoys which mark the entrances to harbours



and the various positions of danger are not always of the same shape and colour. This is for the guidance of the seamen, who, according to the shape or colour of the buoy, are able to distinguish the particular purpose for which it is placed in its position. In the double row of buoys, for instance, which mark the road into a harbour, the starboard buoys—that is, those on the right-hand side as a ship enters—are always conical in shape, and are painted one single colour. The port or left-hand buoys, on the other hand, are can-shaped—that is, they have flat tops—and are painted another colour, or are striped or chequered like a draughtboard. Round the coast of England the port buoys are always striped or chequered, but round Scotland and Ireland they are black, the starboard buoys being red. Buoys used for other purposes are of other shapes and colours.

WHY A TELEGRAPH POLE HAS LITTLE WHITE CUPS

One of the most conspicuous features of the tall poles that support the telegraph and telephone wires is the number of little white cups which we see attached to the cross arms. These are known as insulators, and it is to them that the copper or iron wires which convey the current



are attached. If the wires were attached to some substance like wood or metal, which is a good conductor of electricity, the current, instead of passing along the wire from office to office, would run away to the earth and be lost, and telegraphing would become an impossibility. In order that this may not happen, the wires are attached to the little insulators, which, being made of earthenware, prevent the electricity escaping to the earth. Various forms are used.

WHY THE GLOUCESTERS WEAR A BADGE BACK AND FRONT

Men of all regiments wear a badge on the front of their caps, but the men of the Gloucestershire Regiment wear a badge both back and front, and when seen from behind they look as if they had put their caps on wrong side round. This wearing of two badges has an interesting piece of history behind it. During the Napoleonic campaign in Egypt,

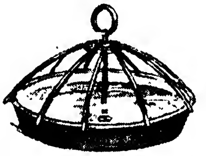
more than a century ago, this regiment was attacked by French cavalry in the rear as well as in the front, and as there was no time or opportunity to form a square, the orthodox method of meeting such an attack, the commanding officer gave the order, "Rear rank, right about face!" The men obeyed, with the result that the French were driven off. To commemorate the gallant behaviour of the men on that occasion, the regiment was given its second badge.

WHY CARRIAGE-LAMPS HAVE LONG HANDLES

THE candle-lamps used for lighting broughams, dog-carts, and other carriages have long, handle-like arrangements underneath. These handles, which are hollow, serve a double purpose. In the first place, they fit into sockets on the vehicle, and thus keep the lamp in position while it is in use. But there is still another useful purpose served. Inside the hollow handle is a spring. When the candle is put into the lamp it presses down the spring, and a cover arrangement allows only the wick to appear above in the lamp proper. As the candle burns shorter the spring presses it up against the covering disc, and the lighted wick is thus always kept at the right height in the lamp.

WHY FOWLS' DRINKING-TROUGHS ARE FENCED IN

A VISIT to any up-to-date and properly conducted poultry farm will show that the drinking-water for the birds is placed in a vessel that has some kind of protecting fence or barrier to it. This barrier, while it does not keep out the head of the fowl. prevents it getting any more of its body in contact with the water. Such an arrangement, especially on a large farm, prevents a great deal of waste both of water and time. Fowls are very fond of scratching, and when the water is in an unprotected vessel the birds soon knock the pan over and spill the water. This necessitates a very frequent filling up of the water-pans and wasting of the poultry-man's time.



WHY PRUNING SHEARS HAVE CURVED BLADES

THERE are two curious things about pruning shears that we cannot fail to notice. They are curved—as shown in the picture—and while one blade is sharpened to a keen edge, the other remains unsharpened. Both these arrangements are to assist in the work that the shears have to do. The unsharpened blade, the concave one, enables the instrument to get a grip of the twig, so that the sharpened blade may cut it; and by curving this blade as shown the cutting motion is helped, the keen edge in the movement being drawn across the twig much more noticeably than would be the case with a straight blade or one only slightly curved. To prove this, try to cut a stout, woody twig with a pair of sharp scissors and see how difficult it is.

WHY SOLDIERS SALUTE BY RAISING THE HAND

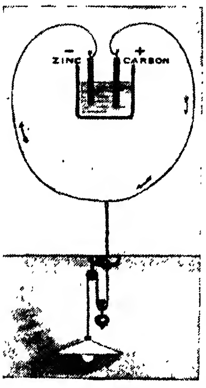
WE have all seen a great deal of military saluting during the war, and it may appear curious that this should be done by raising the hand to the head. The custom is a very old one, and is said to have originated in the tournaments of the Middle Ages, where the knights who were taking part in the contests used to salute the Queen of Beauty on her throne. As they passed in procession before her they shielded their eyes with their hands as a token that the blinding rays of her beauty dazzled them. The movement gradually became a more formal one, and was in time extended until it became the general method by which soldiers greeted one another.

WHY A MILK-CHURN TAPERS AT THE TOP

IT will have been noticed that the large milk-cans known as churns, in which milk travels on the railways, are all of the shape shown in the picture. They have a large base, and gradually taper towards the top. This has been found in practice the most stable of all shapes, and to knock a churn over, especially when it is full of milk, would require a great effort, and far more force than is likely to be exerted by any ordinary accident. The shape is, of course, based on scientific principles. As long as a vertical line drawn from the centre of gravity of an object falls within its base, the object is in stable equilibrium—that is, cannot fall over of itself, or with a slight exertion of force. And in the case of the churn, the base being so much wider than the top, and the centre of gravity, owing to the shape, being so low down, it requires a very severe tilt to throw this centre outside the base circumference.

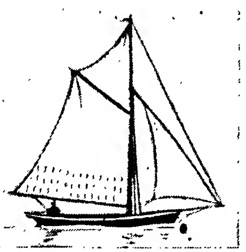
WHY AN ELECTRIC LAMP-WIRE IS TWISTED

THE wire by which an electric-light pendant is supported is always twisted, and there is a reason for this, which will become plain when we remember how it is that the light is caused. A current of electricity is passed from a battery, or accumulator, through a piece of thin platinum wire, which, on account of its resistance to the current, becomes incandescent, or white hot. In order that the current may pass there must be a complete circuit—that is, the current must pass from the positive pole of the battery, through the wire and lamp filament, back along another length of wire to the negative pole of the battery. There must thus be two wires passing to the lamp, and as these would look very ugly hanging loose, and in the case of movable pendants would not pass over the wheel of the pulley, they are twisted neatly together. In this way they form one cord which will move easily over the pulley.



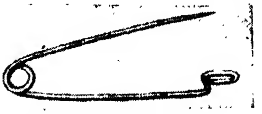
WHY A SHIP'S SAIL HAS A ROW OF CORDS

IF we look at a sailing boat we shall notice that the sails usually have one or more rows of small cords running across it. These hang loosely, and to the person who knows nothing of things nautical they appear to be useless. They serve, however, a very important purpose. In the course of navigation the sails often have to be shortened, or reefed, and this is done by rolling them up from the bottom, to a greater or less extent, as the case may be. The little cords, which are known as reef-points, are tied round that part of the sail which is rolled up, and thus keep it in position.



WHY A SAFETY-PIN HAS A COIL AT THE END

ALTHOUGH safety-pins vary in the shape of the clasp that holds the point when closed, they are all alike in having a coil at the opposite end. This is to give the pin the necessary spring, so that when unfastened it will remain conveniently open for use, and when fastened it may press against the protecting clasp, and thereby be held the more tightly. The coil is the simplest form of spring that can be devised for a piece of metal made all in one piece, hence its universal use for the purpose in safety-pins. Its origin dates back to very ancient times. The Romans used it very generally, and an old Etruscan brooch has been found with a double coil and a clasp for the point of the pin, which is almost a facsimile of our modern safety-pins.



WHY MILK-CANS ARE OVAL IN SHAPE

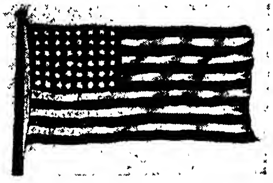
THE cans in which the milk is delivered every morning at our houses are, it will be remembered, oval in shape instead of being round, like the majority of metal receptacles for food and drink. There is a reason for this, which will be seen to be sound when it is explained. The cans have to be hung round the barrow or cart which conveys them from the dairy to the houses, and, being oval, with flatter sides than if the base were circular, they naturally rest closer to the side of the cart than round cans would do. This makes them much less likely to move about with the rattling of the cart, and so prevents the waste of milk that might be splashed out of the mouths of the cans.

WHY SOME UNION JACKS HAVE A WHITE BORDER

VISITORS to the seaside may sometimes see a ship flying a Union Jack which has a wide white border all round it. This flag is known as the Pilot Jack, and is an indication to those on shore that a pilot is required on board the vessel. The Pilot Jack is, of course, used only by British ships, but a number of other countries follow the same principle, and use their flag with a white border for the Pilot Jack, among them being France, Germany, Holland, Belgium, Rumania, Spain, Russia, and Holland. Other countries use a special flag, and some merely fly the flags P and T of the International Code used by sailors, which mean "I want a pilot."

WHY AMERICA'S FLAG HAS STARS AND STRIPES

The United States flag consists of thirteen stripes, red and white alternately, with forty-eight white stars on a blue background in a canton or rectangular section at the top left-hand corner. The stars represent the forty-eight States of the Union, and a fresh star is added whenever a territory is raised to the dignity of a State. The colonists, at the time of the War of Independence, wanting a flag, adopted that of the East India Company, which consisted of thirteen stripes, red and white alternately, with the crosses of St. George and St. Andrew in the canton. The adoption of this flag was regarded as a happy idea, because the thirteen stripes would exactly represent the thirteen original States of the Union. Later, thirteen white stars, arranged in a circle, were placed in the canton, and when two fresh States were formed the stripes and stars were increased to fifteen. But, with the continued increase in the number of States, the many stripes gave the appearance of shirting, so the original thirteen stripes was readopted, and the stars alone represent the actual number of States.



WHY TELEGRAPH WIRES DO NOT RUN STRAIGHT

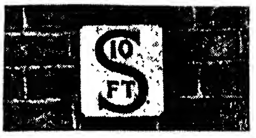
If we look carefully at the telegraph or telephone wires, we shall notice that they do not run straight along from pole to pole, each particular wire being always attached to insulators in the same relative positions as the poles. A wire changes its position at each pole that it is supported upon, so that it will be on the top right-hand insulator first, then at the next pole on the bottom right-hand, at the next on the bottom left-hand, at the next on the top left-hand, and so on. The reason for this is to stop induction—that is, to stop one wire being interfered with by the electric current of another. When the wires run parallel this is a very real difficulty; so the wires are changed about as indicated, to give them a sort of spiral arrangement.

WHY SOME LADDERS TAPER AT THE TOP

In many parts of the country the ladders used are very lightly made, and are wide at the bottom, tapering towards the top. Being light, they can be easily carried about, even by women, and the shape renders them very convenient for use among the trees. The narrow top will stand easily against any part of the branches, and the wide base gives a firm foundation. The ladders used by window-cleaners in towns are also usually of this shape, the tapered top being small enough to lean against the framework of a window without pressing the glass.

WHY SOME WALLS HAVE AN "S" ON THEM

We may often see on the wall of a garden or house a metal plate bearing the letter S with a figure and the abbreviation Ft underneath. The S stands for sewer, and a sign such as that shown in the picture here means that the sewer-pipes will be found at a depth of 10 feet under the path or roadway adjacent to the notice. This is to guide workmen and builders who have cause to dig anywhere in the immediate neighbourhood, to lay foundations, see to a gas-pipe, or for any other purpose.

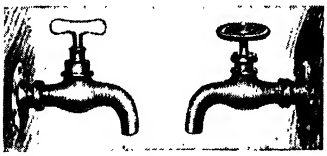


WHY A CANAL BRIDGE HAS IRON POSTS

Where a bridge passes over a canal that has a towing-path at the side, we may sometimes see at each end of the brickwork a stout wooden roller that revolves on an axis. The rollers are to save the ropes by which the barges are towed from being worn by the brickwork. The rollers are found at points where the canal takes a bend, so that as the horse goes round the curve the rope, if it touched the brickwork of the bridge, would be quickly ravelled. Not only so, but the constant wearing would be liable to loosen the bricks. The roller, however, turning as the rope passes over it, avoids any great friction.

WHY SOME TAPS ARE TURNED BY A WHEEL

WHILE the taps and water-cocks in our houses have a flat piece of metal called a bib, by which to turn them, those connected with steam and water pipes in factories usually have a small wheel for a handle. There are two reasons for this. In the first place, a wheel is cheaper, for it has merely to be cast and then dipped in colour, whereas a bib, after being cast, must be filed and polished. Then, in the second place, a wheel is usually found where the pressure is greater and more force is required to turn the tap or cock. The wheel gives a better grip, because, in turning it, the whole hand can be used, and not merely the thumb and forefinger, as in the case of the ordinary domestic tap.

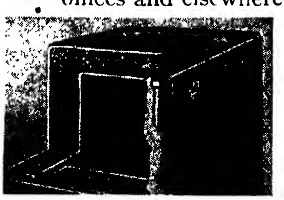


WHY A SAILOR'S COLLAR HAS WHITE LINES

ALL sailors' collars have a border running round them consisting of three white lines close together and parallel. In men of the regular Navy these lines are straight, but the collars of the Naval Volunteer force have the lines wavy. It is difficult to say exactly when the lines came into use or who first originated the idea, but those who have studied the question of uniform state that the lines represent the three great naval victories of Nelson: the battles of the Nile, Copenhagen, and Trafalgar, and are intended to perpetuate the memories of these glorious British triumphs on the sea.

WHY A SAFE HAS THICK WALLS

THE steel safes which are used in business offices and elsewhere for the protection of money and valuable documents have very thick walls, quite out of proportion to the size and capacity of the safe. These walls are not solid sheets of thick steel or iron, but consist of two sheets, each about half an inch thick, with a space between them, which is filled up with a special kind of chemical packing. It is this packing, as much as the steel plates, which enables the safe to resist fire, for, should the building get burnt in which the safe stands, and the flames play upon the walls of the strong-box, the heat passing through the steel sets up a certain action in the packing which develops moisture, and this moisture lowers the temperature of the outer steel wall and prevents it getting red hot and the heat passing to the inner steel, and so to the contents of the safe.



WHY SOME IDOLS HAVE MANY HANDS

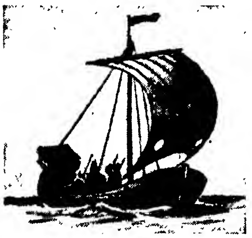
STATUES, images, and pictures of the Hindu deities, such as Vishnu and Brahma, are more often than not shown with four or more hands, and in some cases there are as many as twenty. This is not done to give a grotesque appearance to the image, but is intended to convey an idea to the beholder of the power and activities of the deity. His various hands will be holding many different weapons and symbols, and the maker of the image, or painter of the picture, suggests by this that he is able to act at one time in many different ways. Similarly, as many as ten heads will be given to one deity to show his omniscience and wisdom.

WHY A PIG HAS A RING IN ITS NOSE

PIGS in the country are often seen with a small ring passing through their nostrils. The rings are put into position while the animal is young, and the farmer has a very definite object in doing this. Pigs are notorious grubbers—that is, they will rub their noses anywhere, and dig away the ground while searching for acorns and other food. In this way they would do a good deal of damage in meadows and paddocks where they may be let loose. The ring placed in the nose causes no pain while they feed and lie about, but directly they begin grubbing the ring causes a good deal of inconvenience to them, and, if they persist, no doubt they suffer some pain from its friction.

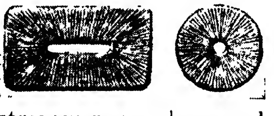
WHY SAILS ARE OFTEN PERFORATED

Sailing vessels often have their sails perforated, though the practice is carried out more by foreign sailors than by British. This is to help the vessel to attain greater speed, and has good scientific support. The value of perforation was first discovered by mariners whose sails had become torn in the wind, and, so far from hindering speed, this was found to help the vessel. As a result the perforations were made by way of artificial tears, and the principle which justifies the practice is this. The wind striking the concave surface of a sail rebounds, and the impulsive effect is hindered. By making a hole, the wind rushes through in a continuous current, and there is no rebound to hinder the vessel's speed.



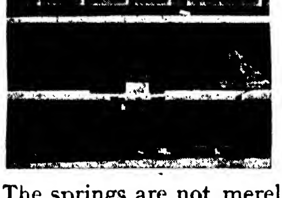
WHY A STRAW MAT HAS A HOLE

The straw table-mats which are so commonly used now have a hole in the middle, and some curiosity may be felt as to why this should be. The reason is to be found in the construction of the mat. The basis of one of these straw mats is a piece of cardboard, and the straw is wound round and round this until the card is completely concealed and only the straw appears to the eye. If the straw were simply wound round an ordinary rectangular piece of card, it would easily slip off, but by having the hole in the middle, and passing the strands of straw through this and round the sides of the card, the straw is kept firmly in position with no fear of slipping.



WHY RAILWAY CARRIAGES REST ON SPRINGS

Railway carriages always rest on powerful springs which are of peculiar construction. Instead of being made of one thickness of steel, as in the case of most road vehicles, they are built up of several layers placed one on top of another, and decreasing in length from the top to the bottom. The springs are not merely for the comfort of the passengers, as some people think, but are to protect the carriage, which would soon go to pieces if it passed continually over points, rail-joints, and irregularities in the rails with nothing to lessen the shock. The various layers have the effect of a number of springs, each absorbing a part of the shock, and united they form a very strong and flexible support.



WHY A GAS-BURNER HAS AN AIR-REGULATOR

All incandescent gas-burners have an air-regulator—that is, a movable perforated arrangement, by turning which to the left or right the holes can be opened or closed. The incandescent gas-burner, it must remembered, is a Bunsen burner in which air is allowed to burn with the gas in order to generate great heat, and the gas is only the illuminant indirectly, and not directly, as in the old-fashioned naked gas-burner. The heat produced by the burning of the gas and air together bring the mantle to a white heat, and it is the prepared earth of the mantle thus rendered incandescent that gives the light. More or less air is needed for burning with the gas, according to changing conditions of temperature, draught, and moisture, and so a movable perforated disc or tube is fitted to the burner to regulate this.

WHY AN ANTHRACITE STOVE HAS MICA IN FRONT

The anthracite stoves which are becoming more and more popular in our homes have a mica front, and there is a very good reason for this. For domestic purposes it is essential that the fire should be seen. A closed-in stove would never be popular, for its appearance would not be sufficiently cheerful. An anthracite stove, however, depends for its success on slow combustion, and, in order that the coal may not burn away rapidly, it is necessary for the stove to be closed in so that a minimum of air reaches the fuel. A mica front is therefore fitted, because, while completely closing in the stove, it at the same time enables the glowing coals to be seen and the effect of an open grate to be obtained.

WHY SOME TREES ARE FENCED ROUND

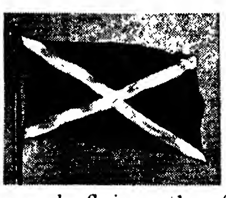
YOUNG trees growing in fields in which animals are grazed are often fenced round, as shown in this photograph. This is to protect them from being damaged by the horses or cattle, which often bite off the bark and destroy the trees. The sap of a tree flows in the layer just under the bark, and if the bark and this layer are removed from a young tree it soon dies. As the tree gets older the fence can be removed, for the bark gets very much harder, and the animals are then unable to injure it with their teeth.

WHY A CALF WEARS A SPIKED MUZZLE

WE may often see in the country a calf wearing a spiked band or muzzle round its nose, as shown here. This is to prevent it taking the milk of the mother cow when that is required for dairy purposes. The spikes on the muzzle, which are, of course, not very sharp or dangerous, merely act as a warning to the mother when the calf approaches, and this plan has been found by experience to be a very safe and effective one for achieving the object in view. Some calves are weaned much more easily than others, and, if kept away from the mother cows, do not, of course, need the muzzle.

WHY A WARSHIP FLIES A ST. ANDREW'S CROSS

WHEN warships are in harbour one of them is nearly always seen flying from her yard-arm a flag consisting of a white St. Andrew's Cross on a blue ground. This means that there is a doctor on board, and that she is the ship that is "medical guard" for the time being. If medical assistance is required on any other warship in the harbour whose own doctor happens to be away, it can be obtained from the vessel flying the flag in question. By this arrangement medical officers of the Fleet are able to obtain leave in regular rotation, one always being left on duty in case of emergency. Where a number of ships are anchored, it is, of course, very essential that it should be possible for any of them to tell in a moment where the doctor on duty is to be found, so that he may be summoned without delay.

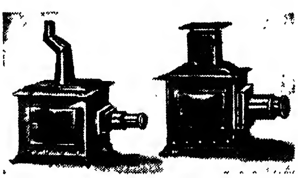


WHY THE R.A.M.C. HAS A SNAKE AS A BADGE

THE collar badge on the uniform of the Royal Army Medical Corps is a laurel wreath surmounted by a crown, with a serpent entwined round a rod. The serpent and rod form a very ancient emblem, which for far more than two thousand years has been connected with the healing art, for this symbol was always placed in the hands of images of Æsculapius, the Greek god of medical science. Serpents were everywhere connected with his worship, because they were regarded as a symbol of renovation, and were believed to have the power of discovering healing herbs. In time the serpent twined round the rod came to be regarded as the god's emblem. For this reason, because of its long association with medicine and doctors, it was adopted for the badge of the medical branch of the Army.

WHY A MAGIC-LANTERN CHIMNEY IS BENT

THE chimney of a magic-lantern is always either bent at two angles, as shown in the first picture here, or, if straight, has a covering, as seen in the second picture. This is to screen the flame of the lamp or gas, and prevent the light from shining upward on the ceiling, thereby illuminating the room and detracting from the sharpness of the picture on the screen. In the older form of lantern the more clumsy method of bending the chimney was adopted, but in modern lanterns practically the same effect is obtained by means of the cover. The chimney, in either of these forms, also acts as a collector of soot where a paraffin-lamp is used for the illuminating power, and thus prevents a considerable volume of smoke and smuts annoying the spectators.



WHY SOME ROOFS HAVE A WIRE GUARD

We may often see on the roof of a house a small wire guard placed along the edge. This is invariably where the roof slants towards the ground, and the guard is so low in height as to be obviously useless to stop a man from falling off. What is its purpose, then ? It will be found that the metal guard is usually over the garden front of a house, and a glance below will show a greenhouse with a glass roof. The guard is to prevent a mass of snow from crashing down upon the glass roof during a sudden thaw and breaking the panes. The snow is stopped by the guard sufficiently to break it up into small portions.

WHY EYE-SHADES HAVE A ROW OF HOLES

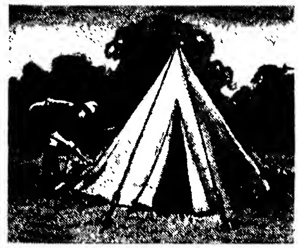
It will be noticed that the eye-shades similar to those shown in the picture, which fit upon the head with two metal arms, have a row of holes along the top. These are necessary if the shade is to be worn for any length of time with comfort. A good deal of heat is given off by the face, and, naturally, the warm air rises, so that if there were no outlet it would be driven up to the forehead and remain there, with the result that the wearer would probably get a severe headache after a time. Not only so, but the heat would be bad for the eyes. The holes, however, allow the warm air to escape, and a constant current of air is maintained, which enables the forehead to remain cool.

WHY A RAILWAY CARRIAGE HAS BOGIES

All the great modern carriages that we find on long-distance trains are so arranged that they have four wheels at each end. The wheels are not attached to the carriage in the same way as the wheels of smaller coaches, which are distributed throughout the length. They are arranged on what are known as bogies—that is, a framework at each end carries the wheels, two on each side, and each framework is attached to the carriage by a pivot, on which it can turn independently of the carriage. A long railway coach thus runs on two sets of bogies—one at each end —and the reason for this construction is that a very long carriage can go round a curve quite safely, because the bogies adapt themselves to the curve, like two small and independent waggons.

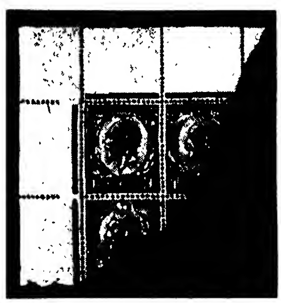
WHY TENT-ROPES ARE SLACKENED AT NIGHT

Every Boy Scout knows how necessary it is at night to slacken the ropes that hold up his tent, and this is also done in the daytime if rain comes on. The reason is the same in both cases. At night, in summer and autumn time, there are heavy dews, and the ropes get wet, just as they do during a fall of rain, and wet ropes always tighten up. The result would be that the rope, having become shorter through the tightening, would either break or pull the tent-pegs out of the ground. In either case the result would be the collapse of the tent, and such a collapse often occurs through forgetfulness to take the necessary precautions. A slight slackening of the ropes gives sufficient latitude for the tightening.



WHY STAMPS HAVE STRIPS OF ADHESIVE PAPER

If we buy any quantity of postage-stamps we usually find there is a strip of adhesive paper attached, and if we purchase a pound's worth of penny stamps we shall find that they are in a sheet of 240 with a strip of the white paper all round the four sides. Stamps of other values are printed in similar size sheets, and also have the paper surrounding them. The reason for the margin is that this gives a certain latitude to the printer. Each sheet of 240 stamps is printed on a piece of paper rather larger than the area of the stamps, and if the imprint is made a little to one side no harm is done, as the white margin allows for this.



WHY ENGLISH STAMPS HAVE MERCURY'S ROD

A NUMBER of our present English postage-stamps, such as the 5d., 6d., 7d., and 8d., have as part of their design the rod of Mercury, known as the caduceus, on each side of the King's portrait. The reason for

placing this on the stamps is that it is considered a very appropriate symbol of those things that are represented by a postage-stamp and the modern postal service generally. Mercury, or, as the Greeks called him, Hermes, was the messenger of the gods, and so his rod with the wings at the top came to be regarded as a symbol of the speed so very necessary in a postal service. Then the caduceus was also the symbol of peace and prosperity, which also go hand in hand with a highly developed postal organisation, and, Mercury being the god of commerce, his rod is further regarded as the symbol of commerce, and increased commerce has been both the cause and the result of the modern postal system. No more appropriate sign, therefore, could be used on a postage-stamp.

WHY THE DOORS OF ROOMS ARE IN THE CORNERS

IN all but the largest mansions the doors of rooms are generally placed near the corners. This is in order to give on the side of the room where they occur the largest possible width of wall for furniture. Were they in the middle of the wall there would be very little space on either side, except in the case of really large rooms. On the other hand, doors are not usually placed right in the corner. Such a position would give a sense of squeezing when entering, so the

door is placed a foot or so away from the actual corner. The door itself, too, is hinged on the side where the greatest length of wall is, so that when ajar any draught entering is broken by the wall at right angles. These positions and devices have been arrived at as a result of long experience and centuries of building and designing.

WHY THE SAILS OF SMALL BOATS ARE POINTED

THE sails of yachts, ketches, and other small sailing - boats are of various shapes, but they are generally pointed—that is, whether triangular or four-sided, they are usually extended in an upward direction so that there is a more or less acute angle. The idea in a sailing-boat is, of course, to get the greatest possible expanse of sail to catch the wind with the least possible weight in the way of mast and yard and spar. Now, as will

be seen in the picture, by extending the sail upwards in the form of an acute angle the area is very much enlarged without the necessity of increasing the height of the mast, for the yard to carry the sail is merely arranged in a slanting position, and thus supports the extension. The bowsprit and jibboom projecting forward from the boat are also for the purpose of extending the sail or sails in another direction, and thus getting more area for the wind to play on than the size of the boat would otherwise allow.

WHY SOME SHOVELS ARE MADE LIKE A GRATING

IN a large factory we may often see a stoker using a curious shovel to move the coal and coke. Instead of being like the ordinary shovel or spade it is in the form of a grating—that is, it is something like a garden fork with a bar across the end of the tips, joining them together. The advantage

of a shovel made in this way for such a purpose is that when the fuel is shovelled up the dust and smaller fragments, known technically as breeze, fall through and are left behind. If a fork were used without the bar across the tips, the prongs would become clogged by the smaller pieces of coke getting caught. These special shovels are usually large in size, so that a considerable amount of fuel can be shifted at each operation. The breeze would clog the furnace, and is generally used by blacksmiths for their forges.

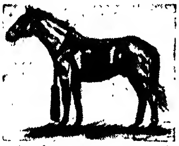
WHY SALT IS SPREAD ROUND A VALUABLE PLANT

WE may often see a layer of salt and lime spread round a plant in a flower-bed so as to form a

complete circle, as shown in the picture. This is to prevent the slugs reaching the plant, the irritant powers of the mixture preventing the pests passing over the barrier. Slugs do a great deal of damage in gardens, but a little trouble and care will save any valuable plants liable to attack. Another useful mixture that is often used in the same way is one of soot and lime.

WHY A HORSE HAS A BOARD HANGING IN FRONT

WE may sometimes see a horse with a rope tied loosely round his neck, and a small board attached, hanging down in front of him. This is a well-known and effective cure for pawing. Some horses have a habit, when they are standing still in the stable or street, of pawing the ground constantly with one hoof. This may not seem to the uninitiated a very bad habit, but horse-owners don't like it, for it uses up a great deal of the energy of the animal, and so, in order to break him of it, they hang the board down in front of the legs as shown in the picture, and then every time the animal paws the ground his knee knocks the board, and in most cases he is quickly cured of his bad habit.

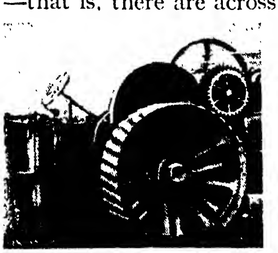


WHY A COTTON-REEL HAS A PROJECTION

MANY cotton and silk reels have a projection on the flat surface at one end, and this may seem to serve no useful purpose. But the reels are made in this way in order to render them more serviceable for a certain use. It will be found that the reels or spools so made all have wound round them a cotton or silk that is suitable for use on a sewing-machine, and the projection, which is much smaller in diameter than the complete end of the reel, is so placed that when the reel is in position on the sewing-machine a smaller surface of it will be in contact with the machine as it revolves, and so the friction will be reduced. The thread is thus less likely to be snapped, as the tension upon it is less.

WHY TRACTION ENGINES HAVE GROOVED WHEELS

TRACTION engines and steam-rollers nearly always have one pair of wheels grooved—that is, there are across the width of the tyre or part that touches the roadway slanting projections. These are to enable the wheels to grip a greasy road when the engine is pulling such a heavy load that its progress is retarded or stopped by the dead weight behind. The projections "bite" the road and enable the wheels to get a suitable leverage, so that the whole vehicle can move forward. We may have noticed that where old traction engines are not fitted with this device the drivers are often compelled on a wet, smooth road to get down and place sacks in front of the wheels to enable them to get a grip.

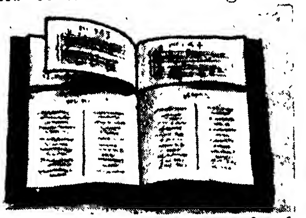


WHY MILLERS MIX THEIR FLOURS

BREAD is not made from one particular kind of flour, but is made from a mixture of two or more varieties, usually from a home-grown and a foreign wheat combined. The reason for this is that the home-grown wheats are what is known as "weak," and if made into bread produce a small, flat loaf. It is necessary, therefore, to strengthen them by an admixture of Manitoban or other foreign wheat in order that the bread may bake into a large, well-risen loaf of uniform and porous texture. The "strength" referred to is an indefinable quality that is not yet properly understood, but it is really a capacity to produce appetising, well-risen bread. This picture shows on the left a loaf made from English-grown wheat, and on the right a similar loaf from an equal quantity of Manitoban wheat. Successful attempts are now being made to grow strong wheats in England.

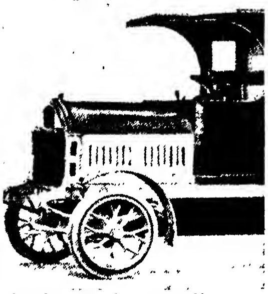
WHY PSALM-BOOKS HAVE DIVIDED PAGES

THE books of Metrical Psalms and Scripture Paraphrases used in the churches of Scotland have the pages divided, so that they appear like two books placed one above the other and bound in one cover, as shown here. This is a very useful arrangement for the book in question, and facilitates the singing. The Psalms and Paraphrases are in one or two familiar metres, and so the same tunes can be sung to a large number of the Psalms. In order, therefore, that when a piece is to be sung to a certain tune in another part of the book the tune and the words may both be before the singer at the same time, the pages are divided in the way indicated, and the words and music can then be turned over independently until any required tune can be in position above any Psalm or Paraphrase. In an ordinary hymn-book, where the metres and the times are far more numerous and varied, this is not necessary.



WHY A MOTOR-BONNET HAS SLITS

MOST motor-lorries that are driven by petrol-engines have a number of slits on each side of the bonnet that covers the engine in front. These are shown in the picture, and if we look carefully at a lorry-bonnet we shall notice that each slit has a small projecting shield running its whole length from top to bottom on the side nearest to the front of the lorry. The slits are to allow of the escape of the heated air from the engine. As the lorry moves along, cool air rushes into the bonnet through the front of the radiator, and when it is warm it passes through the slits, so that a constant stream of cool air is playing through the bonnet all the time.

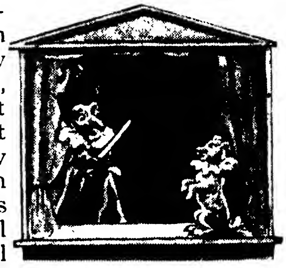


WHY CHURCH WINDOWS HAVE BLACK LINES

IN stained-glass windows we usually find a number of thick black lines, most of them following some outline of the design or figures in the picture. In the early days of stained and painted glass, only small pieces of the material could be produced, none of them sufficiently large to fill any but the smallest windows. In large windows, therefore, it was necessary to have a framework of some kind into which the glass could be fitted, and, naturally, this was made to follow the outline of the design as much as possible, to avoid disfiguring the window. The binding thus grew to be an integral part of the design, and in modern stained-glass windows, when there is less need for the supports, the custom is still followed.

WHY DOG TOBY WEARS A RUFF

IN all well-appointed Punch and Judy shows it will be noticed that dog Toby wears a Tudor ruff round his neck, and Punch himself is usually shown also with a kind of ruff. The ruff is worn now in each case, of course, because it is a recognised part of the costume of each character, but this item takes us back to the days when the Punch and Judy performance originated in Italy. This was about the year 1600, when Queen Elizabeth was on the English throne and the ruff was an ordinary article of dress. It was therefore natural that the characters of the new puppet show should be dressed in the costume of the period. The exhibition soon spread from Italy to other countries, and in England it reached the height of its popularity in the eighteenth century. This is why Judy is still dressed in the usual Hanoverian mob-cap and ruff. The name Punch means a "little chicken," and this is why Punch has his squeaky voice. It was originally an imitation of a chicken's squeak.



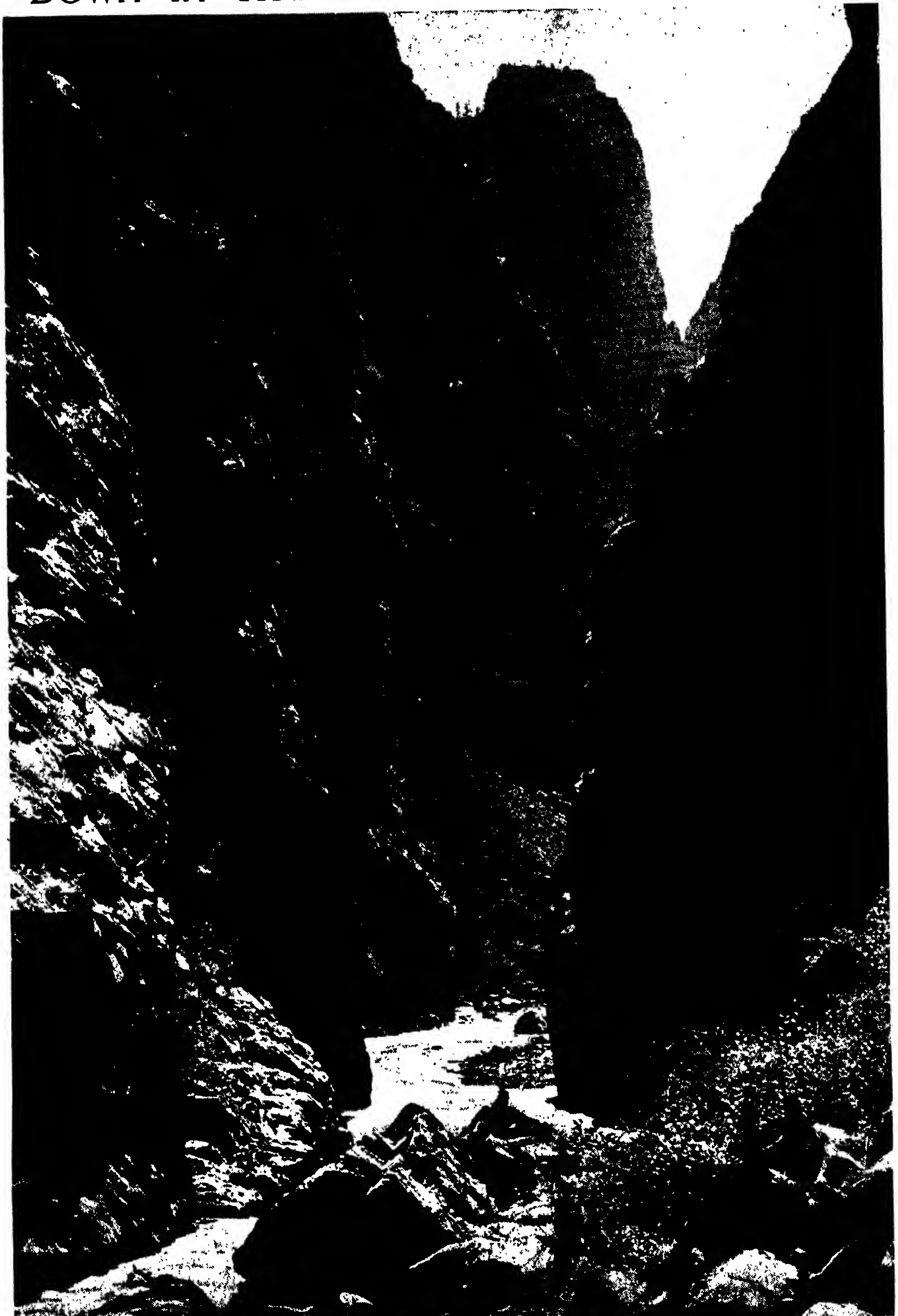
WHY 6 AND 9 SOMETIMES HAVE A STROKE ON TOP

WHERE plain cards or discs, each with a single figure, are used for any purpose, as, for instance, in warehouses for marking stacks of goods, and so on, we may often see that the six and the nine have a small, black, horizontal line across the top of the figure. These figures are, of course, identical in form, except that one is in the reverse position of the other, and if there were no sign on a card to indicate which was six and which was nine the two might easily be confounded. The small line, therefore, is put at the top of the figure, as shown here.

WHY SOME POULTRY-HOUSES ARE MOVABLE

ON farms where fowls are kept, we shall generally find that the poultry-houses are movable structures, often arranged upon wheels, and, if large, fitted with shafts, so that they can be conveniently moved about. There is a very good reason for this. In the first place fowls never thrive so well when kept together in large numbers, hence the advantage of distributing them about in a number of smaller houses; and in the second place the farmer by having movable houses is able to shift his fowls about on the different fields, to the great advantage of the land, and after the harvest is gathered the portable houses can be moved to the stubble-fields, where the fowls can find their own food and thus cheapen the cost of their upkeep.

DOWN IN THE DEPTHS OF THE CANYON



THE GUNNISON RIVER WINDING ITS WAY THROUGH THE FIRE-FORMED ROCKS

THE INCREDIBLE JOURNEY

HOW MEN TOOK A RIVER THROUGH THE SOLID ROCK

Here is the story of one of the greatest things ever done by the hands of men. It is the story of a man and a mountain barrier—a mighty granite wall that stood between a river and a thirsty land.

A thousand feet, two thousand, three thousand feet the walls rose from the rushing waters, and into the dark canyon below no man had ever set foot. The sun could not reach its depths, save for an hour or two here and there; the foot of these rocks on the water side was one of the unknown regions of the earth. But on the other side lay a great plain ablaze with sunlight, waiting only for water to make it blossom as the rose. Why not turn the river through the mountain?

It was the thought of a dreamer, but it came to an adventurer, and it was done. This is how they did it.

ONE morning seventeen years ago a curious telegram was received at the headquarters of the Reclamation Bureau at Washington, the department of the United States Government which deals with irrigation and reclaiming of waste and desert lands.

"Can the Gunnison River be made to water the Uncompahgre Valley?" said the telegram; and it was signed "Lauzon," a name unknown to the engineers of the department. In cold print the telegram may not appear very remarkable, but the engineers who received it rubbed their eyes and read it again and again. They thought it must be a joke, or, at any rate, that it must have been sent by somebody who knew nothing of the river and the valley.

The Uncompahgre Valley was a great tract of wilderness land in the south-west of Colorado. It might, in a happier natural environment, have been a garden that blossomed as the rose, for the soil was rich and the climate kind, but, unfortunately, there was little or no water, and Americans came to speak of it as "the land that God forgot." True, there was a stream, the Uncompahgre River, the waters of which had, at infinite pains, been diverted into the valley for irrigation purposes, but in summer this became a trickling brook, and if the season was very hot the water was soon all used up, and the valley became a desolation.

Away on the north-east of the valley rose a range of forbidding mountains, with almost unscaleable precipices towering up two thousand feet and more into the sky, and on the other side of these mountains, with a wall of solid rock six miles thick between it and the valley, ran the Gunnison River, a rushing torrent of abundant water. It was the very thing the valley needed to give it life, and yet the river was as much cut off as if it were in another world.

No wonder the engineers of the Reclamation Bureau looked at one another and at the telegram with surprise. Could this unknown Lauzon understand what he had written?

And who was Lauzon?

Well, Lauzon was a Frenchman blessed with a marvellous imagination; not a wild dreamer of impracticable things, but one whose imagination had the magic power of inspiring other men to achieve the impossible. At any rate, that is what his telegram was to do, for it was the very beginning of the most daring, the most difficult, and the most spectacular of all the mighty irrigation works that man has carried out in the desert lands of the Old World or the New.

Some years before, Lauzon had gone with others into the Uncompahgre Valley, then a barren wilderness, determined to change it into a fruitful valley. There was no water to feed that part of the valley where he had settled down, but Lauzon and his friends brought the water of the Uncompahgre River to their fields and orchards, and for a time all went well. The little farms of the settlers extended over about forty acres each, and the waters of the river were, for

a year or two, sufficient for their needs. But other settlers began to tap the stream and share its waters, and when there followed several dry seasons, the water was soon exhausted, and desolation overtook the little colony. Yet all this time, six miles away, on the other side of those forbidding mountains, ran the Gunnison River, carrying thousands of millions of gallons of life-giving water through the Black Cañon into the Colorado River, to be lost in the Pacific Ocean.

Why Not Annihilate the Mountain and Let the River Go Through?

It was here that the imagination of the enterprising little Frenchman helped the world. Why not annihilate the mountain barrier and bring the Gunnison River through to the valley, where it could give life and healing? The Alps had been pierced for a railway more than once; why not pierce the mountains of Colorado and compel the wild river to go through to the valley, there to be tamed and harnessed for man's use? It was this great idea that led to the telegram.

The engineer who received the message at the Reclamation Bureau was Mr. A. L. Fellows, and he handed it to his colleague, Mr. W. W. Torrence. The men looked at one another; the magnificent daring of the suggestion appealed to them. They knew the valley and the river well, and they knew the mighty mountain barrier that lay between. They realised the enormity of the task, but they were the sort of men whom nothing could daunt, and for whom difficulties were things to be got over.

The Unknown Depths Down Between the Mighty Walls

If the Gunnison River was to be turned into the valley, a gigantic tunnel must be driven through the solid rock from some point in the Black Cañon, but there was the first difficulty. The terrible cañon, a mighty chasm nearly three thousand feet down, with rugged precipices and juts of slippery crag on either side, had never yet been explored by man. Some had gone into the cañon to attempt it, but had never been heard of again. Never had human eye seen those awful depths; for the best part of the year sunshine never reaches them, and a dim daylight lasts for only a few hours out of the twenty-four.

The Gunnison River is one of the largest streams in Colorado, and its many heads drain a thousand square miles, but its valleys are narrow, descending in ever-deepening gorges until it finally plunges into the Black Cañon. Gunnison, the explorer, who gave his name to the river, followed its course through valley and mountain and forest until it was swallowed up in the dark recesses among the giant crags; and so forbidding was the place that he called it the Black Cañon. He dared not venture into its inky depths, and it was not until nearly a quarter of a century later that another attempt at exploration was made. This time it was made by the officials of the Geological Survey of the United States, but their director, Professor Hayden, declared the cañon to be absolutely impenetrable.

The Beginning of the Terrible Voyage that No Man had Made Before

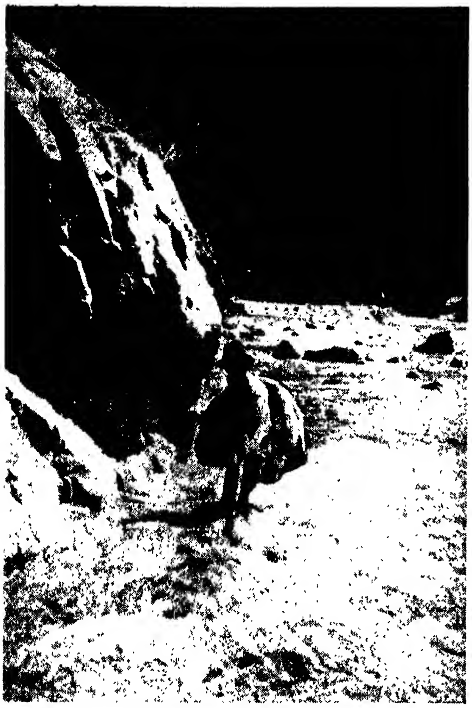
Some of the geologists had been lowered down the rocky walls by stout ropes, but at a depth of a thousand feet they signalled to be pulled up again. "No man can descend the cañon and live," they said, and this was confirmed by the native tribesmen, who declared that no native who had ventured down had ever been heard of again.

But Mr. Torrence determined to explore the cañon. To descend by ropes from the top of the precipice was impossible, for the stoutest cables would be frayed and cut by the sharp rocks long before their human burden could reach the rushing river half a mile or more below. There was no alternative but to do what no other man had ever dreamed of doing—to enter the cañon with the river, and, venturing into the unknown, chance whether an exit could be found.

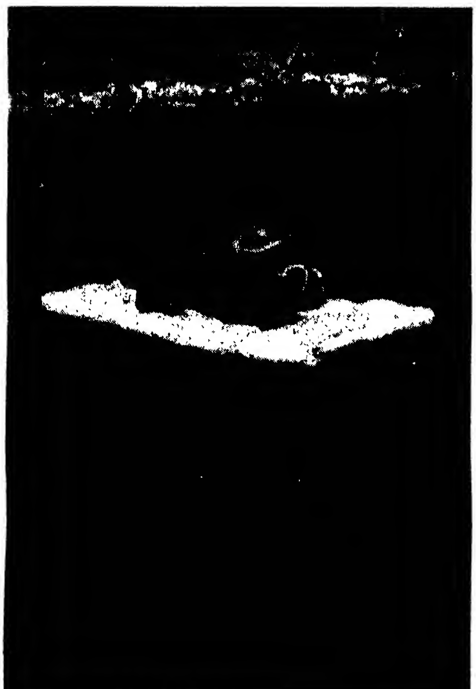
No man ever made a more daring or a more perilous voyage. If in the unknown depths of the great cañon the river took strange turns and

CLIMBING UP THE TERRIBLE CANYON WALLS

CLIMBING ALL DAY, THE MEN WERE NOT AT THE TOP WHEN NIGHT CAME ON, AND HAD TO GROPE THEIR WAY IN DARKNESS



CARRYING A CANVAS BOAT THROUGH THE RIVER



FELLOWS PUSHING HIS BED DOWN THE RIVER

broke over deep cataracts, the stoutest boat would be smashed like a shell, but no danger could deter the intrepid engineer from making the attempt. The idea of harnessing a mighty river and forcing it where it might work incalculable benefit for mankind had inspired his imagination, and he hesitated at nothing.

He got three or four volunteers to accompany him, with two boats specially constructed of oak frames covered with canvas, so that if they were damaged on the rocks the damage could be easily repaired, and he arranged to have boats, stores, and crew lowered down the cañon at a point fourteen miles from where it was supposed that a tunnel might be driven. At this chosen point the rocks, though fifteen hundred feet deep down sheer precipice, were negotiable. The journey, it was reckoned, would occupy a month, and for food tinned meat and vegetables alone were to be taken. Cameras, surveying instruments, and notebooks were packed in tins to protect them from the water.

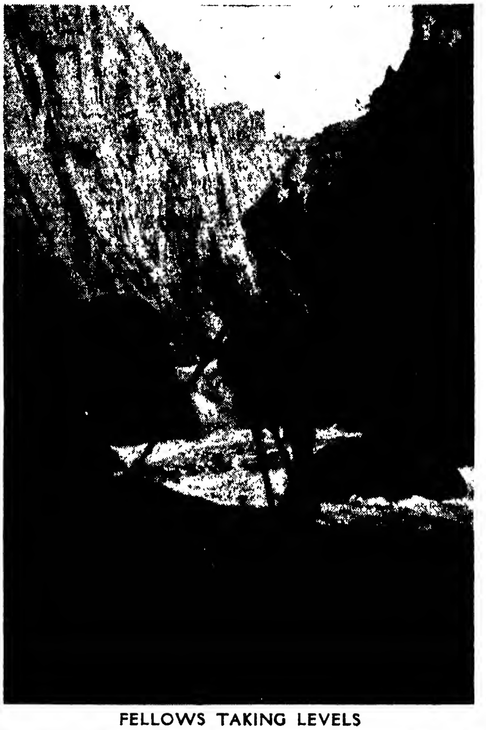
When all was ready, the party, with a number of helpers and friends, proceeded to the spot, and Torrence and his four volunteers were lowered with their boats and stores. It was an anxious time, for many things might happen during the journey to the depths, but in due course those waiting and listening at the top heard revolver shots fired from below—a signal which told them that all had reached the river in safety.

It had been arranged beforehand that men should be stationed along the top of the cañon at intervals, in case, at certain points where the river was visible for a short time each day when the sun shone directly down, the explorers might be seen. At any rate, if that was impossible, it was thought that revolver shots from below could be heard, indicating that the explorers were proceeding safely, and the glad news could be conveyed to their anxious friends and relations. But days went by and not a sound or sight had reached

the watchers above, and all hope was at last given up, and wire nets were stretched across the river at the mouth of the cañon, in the hope of recovering the bodies of the men.

Then there came a great surprise. A watcher peering down into the depths through a field-glass one day spied what seemed to be several little dots moving from rock to rock, and realised that these must be the explorers, and that they still lived. He shouted himself hoarse and fired revolver shots, but the roaring and raging of the waters below prevented the sound from being heard, and so, in order to attract their attention, the overjoyed watcher threw a small stone down some distance ahead of where the explorers were seen, and a remarkable result followed. This detached a larger stone, which set moving a piece of rock, and before long a ton of rock was crashing down the side of the precipice, and finally plunged into the river, hurling a geyser of water a hundred feet into the air, some yards ahead of where the explorers were struggling. It had the desired effect. The signal was recognised; the men looked up and waved.

What had happened to these brave and daring men down in the cañon? There, where daylight at noon was little better than dusk, where the torrent roared so that the men could only communicate by shouting into one another's ears, where the water was as cold as ice, and hurled itself with such fury against its prison walls that the spray flew thirty feet into the air, and the icy stream drenched the men till they were always wet to the skin, it was only by the supremest effort at the outset of their voyage that the men could preserve their boats and stores. Over rocks and boulders, worn as smooth as ice, they had to scramble and pull each other, all the time holding fast to the ropes attached to their boats. Then they would come to a stretch of comparatively smooth water, and would be able to embark again, but before long there would be still more dangerous rapids than the last, where

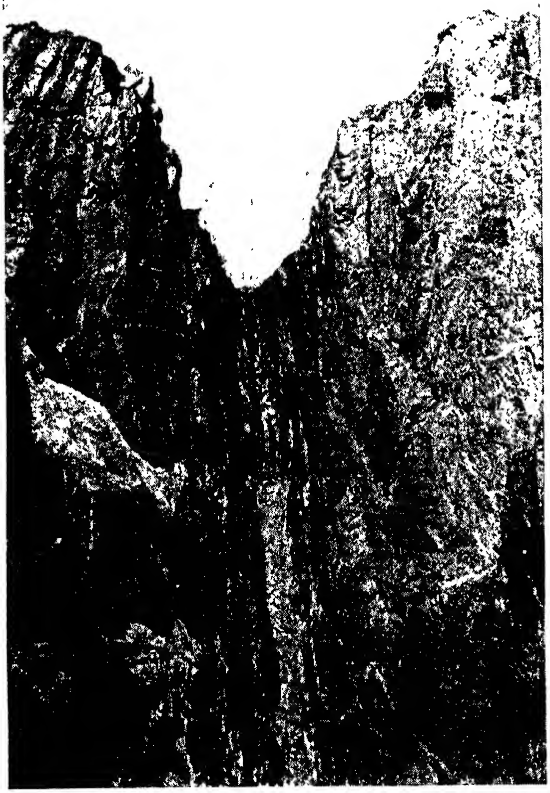


FELLOWS TAKING LEVELS

FELLOWS SWIMMING DOWN THE RIVER

the water foamed and rushed and lashed, so that only by tying themselves together like Alpine climbers could they battle through it, knee-deep, dragging their boats after them. Thus they moved slowly on their first day, until at four o'clock, with the dusk of the depths changed to the pitch-blackness of premature night, they had traversed only three-quarters of a mile from the point at which they started.

Wet to the skin, cold and miserable, with the roaring that prevented any connected and continuous conversation, they had to stretch themselves on the cold, wet rocks, eat a cold meal, and remain almost immovable until eight o'clock the next morning, when sufficient light had penetrated the cañon to make further travelling possible. The second day was even worse than the first. Cold and stiff, the poor men rose from their hard, wet beds, and set out, but they had not gone very far when a rope broke, and one of the boats, with its valuable store of food, was dashed away, and never seen again.


THE WALLS UP WHICH THE TWO MEN CLIMBED OUT OF THE CANYON

Fortunately, they came across a cave in the wall of the cañon which they explored, but could never reach the end, and here they spent their second night. So it went on. "For five days they travelled," says a writer who has told the story of this amazing voyage, "working their hearts out, slipping and floundering up and down wet, glassy boulders, treacherous as glare ice, and by night twisting miserably through long hours. Worst of all, owing to the loss of a boat with its load of provisions, it was necessary to cut rations. They were growing weak for want of rest and proper food, for lack of the sunshine and the blue sky, a patch of which they could see by looking straight up, and more than a narrow strip of which they might never see again. By night they lay, face upturned, amid spume and spray and din, in an atmosphere like that of a tomb, while overhead hung a strip of placid stars. With energy and vitality running low, courage dwindled, and to the suffering of the body were added torments of the soul. Retreat against that volume of hurling water was out of the question. Somewhere ahead, where the cañon grew deeper and deeper, there was one chance in a thousand of finding an unknown watercourse, or a fissure up which they might climb. Failing this, starvation stared them in the face."

When the attention of the explorers was attracted by the plunge into the river of the mass of rock set rolling down the cañon, they had been travelling for nearly three weeks. The gorge now became narrower and

deeper and darker. For long distances there were no banks or rocks on either side on which a foothold could be obtained. To travel in the boat was to risk everything, and there was nothing for it but to swim, clutching at the gunwale of the boat for support. just ahead the river disappeared into a fearsome tunnel, formed by millions of tons of rock, which had through the years and ages fallen from the crags above. They could not go into the unknown tunnel, but they started to climb over the rocks and dragged their

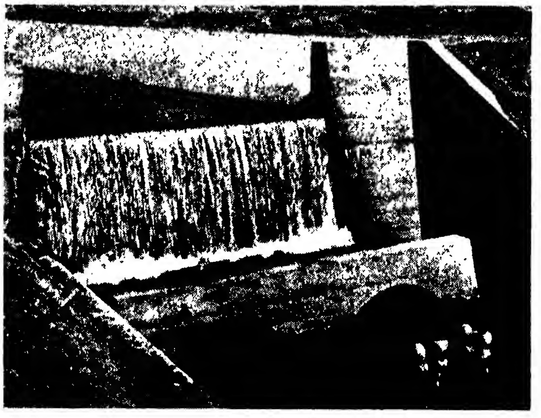
THE END OF THE PERILOUS PASSAGE—ONE HERO SAVES THE OTHER

The beetling walls of the cañon rose to between two and three thousand feet, and it became clear to the men that it would be impossible to go much farther. The short rations and the constant strain and stress, with the cold and damp, were telling upon their health. They were woefully pale, growing weaker and weaker, and wondering if they would ever see the world and their friends again, when boat with them. For a whole day they struggled, and then, when they came down to the river again on the other side of the mass of fallen rock, they found that the walls now rose to a height of nearly three thousand feet, and narrowed down to twenty-eight feet wide, with the water rushing through like a mill-race, and a cataract ahead, which, in their misery, they named the Falls of Sorrow. To

attempt to navigate such a torrent would have been madness, but even then the men did not despair. "With our present equipment we can go no farther," wrote Torrence in his note-book, the last entry made during the expedition. "The Black Cañon is *not* impenetrable. If I get out of this alive, I shall come back."

The all-important question now was how the men were to get back into the world of life and light. It was the brave Torrence again who brought hope to his comrades, for he spied ahead what appeared to be the bed of an old water-course, running zigzag down the steep sides of the precipice. At places the angle was eighty degrees, and the men could not see very much of the course, but there was just a chance that, roped together like Alpine climbers, they might struggle to the top. At any rate it was their only hope of life, and they determined to try it. To carry a heavy load would be impossible, and so the men sat down and ate plentifully of their remaining stores, taking with them only enough for one more meal. They must begin the perilous ascent at the first sign of daylight in the morning, and push on with every possible speed, or they would be overtaken by the darkness of night on the face of the precipice.

THE CANAL RUSHING DOWN TO THE VALLEY



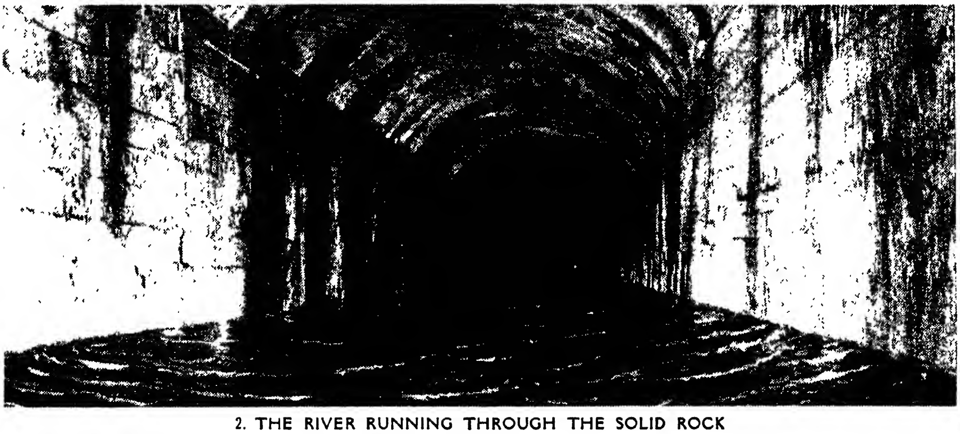
THE FALLING OF THE WATERS

Torrence led the way, and the tortoise-like procession began to creep up, the danger being that those in front might dislodge heavy masses of rock and send them hurtling down upon those who followed. By noon they had climbed a thousand feet, but still more than fifteen hundred feet of beetling crag frowned down upon them from above. The exertion of climbing had given them fierce appetites and a raging thirst, but these they could not satisfy. They must press on, and all the time they had the sickening dread that the leader might suddenly announce that the course was blocked and all further progress barred.

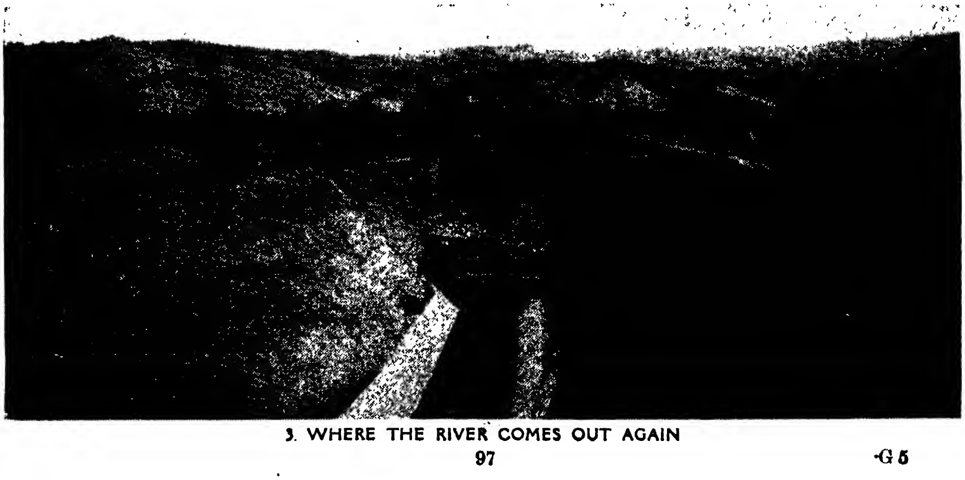
When they had reached a height of two thousand feet, night closed in, and there were still five hundred feet more to scale before the top was reached. There they were, weary beyond description, their limbs stiff, their throats parched, their lips swollen and purple for the want of water, their hands and legs cut by the jagged rocks, their eyes swollen and bloodshot, and their pale faces

THE NEW WAY THE OLD RIVER GOES

1. WHERE THE RIVER RUNS INTO THE MOUNTAIN



2. THE RIVER RUNNING THROUGH THE SOLID ROCK



3. WHERE THE RIVER COMES OUT AGAIN

covered with a thick mask of solidified dust. To remain for a whole night in such a condition was clearly impossible, and, despite the darkness and the danger of their plight, they felt they must press on. For five hours more they struggled on, not seeing a step before them, but trusting entirely to the sense of touch, when Torrence gave a shout. He had suddenly pulled himself up into a position where the starry sky lay spread out before him, and the horizon glittered all around. One after another the men climbed to the brink, until at last all were safe back in the world of their friends, having taken twenty-one days to cover a distance of fourteen miles. On this occasion the Black Cañon had won, but Torrence, and Fellows, to whom he made his report, determined that the victory should, before long, be wrenched from it.

The Strange Craft with which the Two Men Went Into the Cañon

The two men planned and plotted for a year. Torrence's experience, rough as it had been, showed that the cañon could be explored as far as the Falls of Sorrow, but the next time the exploration must be carried right through to the end. And now began one of the most remarkable and difficult feats of surveying ever attempted in the history of engineering. Boats were useless, and so the two men, who had determined that this time they would go through the cañon together without any other companions, invented a special raft, consisting of a rubber air-mattress divided somewhat like a Zeppelin into independent air-compartments. This was fitted all round with hand-ropes, by which the men could support themselves when wading or swimming, and their food, notebooks, and apparatus were sealed up in watertight bags and lashed to the raft.

With this strange craft they entered the cañon as before, and after a fortnight reached the Falls of Sorrow. So far the journey had been a little easier than the first, but now the explorers had once more come face to face with the unknown. Swimming, and holding on to the raft, they plunged over the falls into the mysterious gorge. For days they were wet to the skin, cold and chattering, and at places the danger was so great that they lashed themselves to the raft, a precaution that saved their lives, for on several occasions they became so exhausted that they would have sunk in the stream or been dashed on the rocks had they not been secured.

Down, Down, Down in a Boat, Through Dark, Rushing Waters

Progress was terribly slow. Once they were three hours going twenty yards. For whole days they would be immersed, and then at night so narrow were the ledges of rock on each side of the river that only by taking it in turns could they get any sleep. There was not enough room on the ledge for the two to rest at one time. As the days passed the difficulties increased, food became scarce, the men's strength began to get less, and all the time the cañon grew higher and narrower, and hardly any daylight at all penetrated, even when the sun was at its height. The river was rushing faster and faster down towards what might possibly prove to be a deep waterfall, over which the men would be dashed to instant death. Sure enough, as they came round a bend, they saw, a hundred yards ahead, that the river did disappear over a ledge. Working to the sides, they found the water so shallow that they could wade, despite the current, almost to the edge of the brink, but they were quite unable to see whether the river fell upon rocks or into a basin, where they might have some chance of life.

The Plunge Over the Brink Into the Unknown Depths

For a time they stood in despair, but there was no way out save to follow the river over the brink, and it was finally decided that Fellows should take the plunge first, and that Torrence, after launching the raft with the instruments, notebooks, and the remains of the food, should follow. Fellows leapt over and disappeared,

THE ROAD DOWN THE MOUNTAIN SIDE

THE ROAD BLASTED OUT OF THE SIDE OF THE MOUNTAIN WALL TO LEAD TO THE WORKS BELOW

THE LITTLE HOMESTEAD OF THE TUNNEL BORERS WHICH IS DEEP DOWN IN THE CANYON

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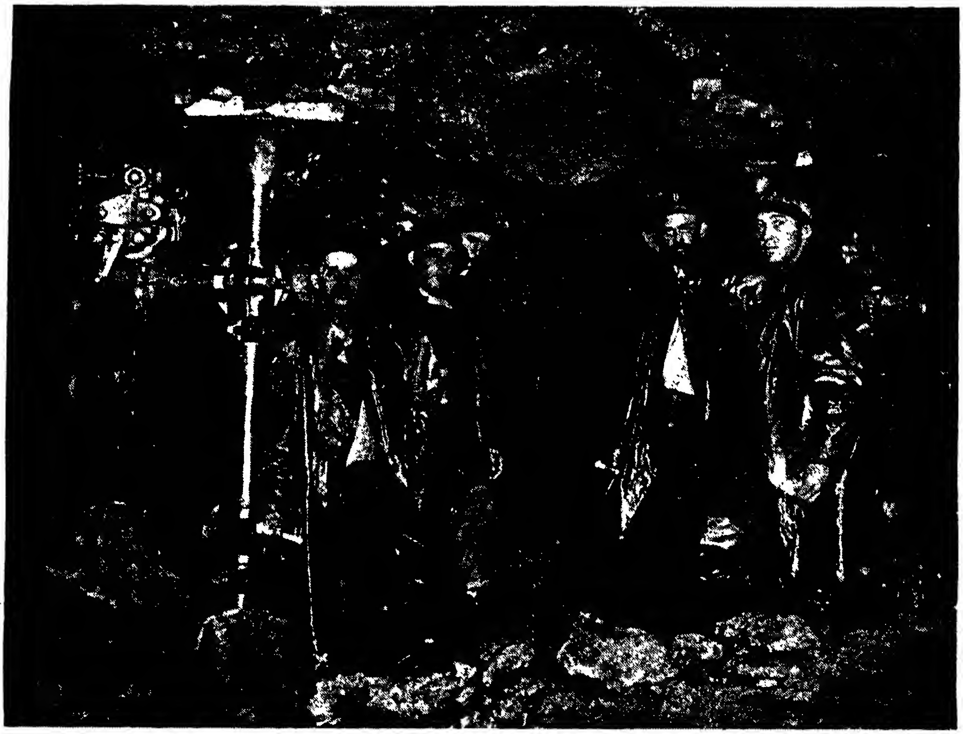
and after five minutes Torrence released the raft and followed. Both men, as they were dashed about in the torrent, lost consciousness; at any rate, they could remember nothing until Torrence came to, clutching a rock against which he had been washed, while Fellows awoke to find himself lying on an adjacent rock. All their strength was gone, and for hours they could do nothing but lie cleft, from where they could not tell, a mountain sheep. Torrence clutched at it and succeeded in holding the animal till Fellows could come to his assistance. Then, famished with hunger, they slew the sheep and ate its flesh as only starving men can eat. How the animal got into such a place will ever remain a mystery, but undoubtedly, by supplying fresh food, it saved the explorers' lives.



THE MEN WHO BORED THE MIGHTY MOUNTAIN BARRIER

and pant. Then, eating the last of their food, they began the journey once more, but in so emaciated and exhausted a state that they made slower progress than ever. They dragged the raft with them, and managed to keep from harm all their photographs and records.

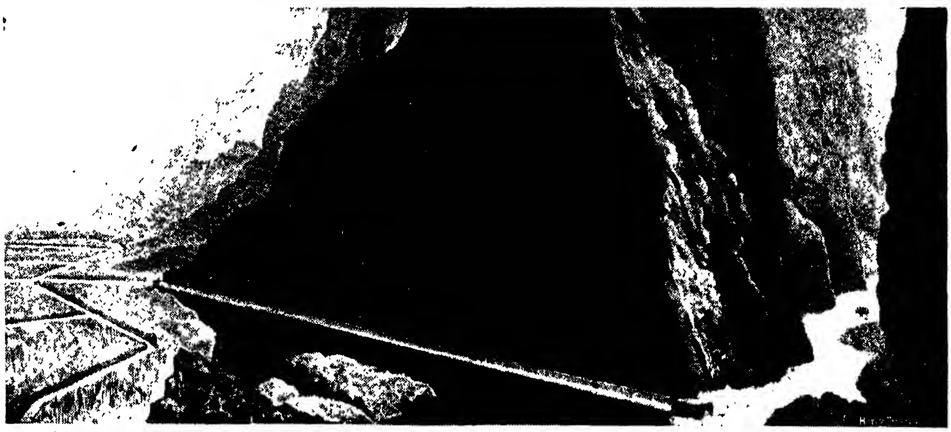
It was not long before their strength gave out. They could continue no further, and, seeing a cleft in the rock, they dragged themselves to it and sat down in despair. But at this moment a wonderful thing happened. There suddenly bounded into the

With renewed strength they again began the journey, and now came the most thrilling experience of the whole adventure. Probably no other man has ever lived through such a terrible ordeal. For ages masses of black rock had been falling from above, and in this narrow part had got wedged between the walls of the cañon, forming a tunnel through which the river rushed in a winding course at terrific speed—a tunnel far longer and more formidable than that leading to the Falls of Sorrow. Mass after mass had fallen until above the tunnel rose a

great volume of rock hundreds of feet high. All escape was cut off; it was quite impossible for the men to go back. To scale either the perpendicular wall of the cañon or the rocks immediately above the tunnel was equally impossible, and there was nothing for it but to let the whirling river carry them into the pitch-black tunnel and chance whether they ever came out again. The most likely thing was that they would be sucked down in the maelstrom, or dashed to pieces against the rocky walls.

The men could not speak, so great was their emotion, but they clasped hands, and then, from the rock on which he stood, Fellows leapt into the whirlpool at the entrance to the tunnel. In an instant he disappeared, and Torrence felt, no doubt, that he must have gone to his death. For a moment he waited, and then, hurling the raft down as before, he followed it and dived into the tunnel. How many moments elapsed he could not say, but Torrence was just losing consciousness when he suddenly felt himself clutched by the collar, and the next moment he had been dragged upon a rock by Fellows, and found himself in a place where daylight was visible. Fellows had, by great good fortune, been thrown against the rock in such a way that he was able to grasp it and pull himself up, and a moment or two later he espied his comrade emerge from the tunnel and dragged him up to a place of safety. For a few seconds the men were silent; then they embraced, and Fellows shouted, "Who says now that the Black Cañon is impassable?" After resting, they found a part of the cañon where they thought it might be possible to climb to the top, and after two days of struggling and danger they reached the summit, having by this time travelled thirty miles along an unexplored part of the river.

They put their survey in order, the Reclamation Bureau studied it, and it was finally decided to cut a tunnel six miles long through the mountains and turn the Gunnison River into the Uncompahgre Valley, as Lauzon had suggested. The final mapping of the cañon, the fixing of the levels, and so on, was carried out by another engineer, Mr. J. W. M'Connell, and his work was almost as dangerous as that done earlier by Fellows and Torrence. At last everything was ready for the actual work to begin. At Lujane, on the Uncompahgre side of the mountains, in the desert, sprang up a wonderful town, with power plant, machine shops, houses, dormitories, offices, and canteens, and fifteen of the most powerful drills were set to work boring into the mountains. At the same time, on the other side, in the cañon itself, a still more remarkable plan was carried out. Before the drills could be set in operation here, a road



THE WAY THE WATER GOES FROM THE DARK, ROARING CANYON TO THE SUNLIT PLAIN

must be made down into the very depths of the cañon along which the massive machinery and the men to work it could pass. By mean of dynamite charges, which sent hundreds of thousands of tons of rock crashing down, a road was hammered out of the solid mountain, and it has been described as one of the most remarkable highways in the world. In piercing the tunnel a world's record was established by the excavation of 823 feet in a single month. As the work proceeded, every kind of difficulty that can arise in tunnelling was encountered. Accumulations of gas were found, subterranean springs and streams were tapped, masses of rock caved in, and underground quicksands had to be timbered. The water was a particularly serious difficulty, and huge pumping appliances had to be installed. Three-quarters of a million gallons of water were pumped out of the tunnel in 24 hours. For ten years the men worked in three shifts day and night, and the average progress made was 250 feet a month. Altogether five million waggon-loads of material were removed from the tunnel, and at last the men boring from the Uncompahgre side could hear the men working from the cañon, and two weeks later the final charge was fired, and the parties shook hands inside the mountain with a million tons of rock above them.

THE WILDERNESS BLOSSOMING AS THE ROSE

In September, 1909, President Taft pressed a button, and the Gunnison River came roaring and bounding into the valley, where it is changing the desert into a garden.

A great day was the opening day, when the waters poured through from the Black Cañon into the sunlit valley. And who was the happiest man there, do you think? He was a little Frenchman, and his name was Lauzon.

What You Should Know

ABOUT MACHINES

You must have thought sometimes, when you have been watching a machine, that its wheels and cranks and levers moved as if they were alive; it would be almost true to say of some machines that they are more alive than some people. They move as if there were a mind within them.

It is, of course, a mind that makes them move, but the mind is without them, not within. There is a sort of sense in matter everywhere, and the man who thinks at all can hardly look on matter without wonder; but the sight of a mass of moving steel, every part of it throbbing as if with feeling and certainly with purpose, has an impressiveness of its own. It means that man is putting his personal powers into impersonal things.

The world has moved a long step forward since James Watt sat looking at the steam in the kettle lifting the kettle-lid. It was almost the first time, at any rate in the modern world, that it had occurred to anybody that steam could be made to do things, and immediately there came into the mind of man a great vision of new powers. If steam would lift up a kettle-lid, it could clearly be made to push things up and down, or this way or that way, or to turn a wheel round. And the moment steam began to do these things there was a sort of mechanical mind in the world, a thing of immense and almost unlimited powers, from which have developed a host of mechanisms that no man can number.

But think of the lines on which they have developed, think of the thousands of parts in a single machine, all working together. If one goes wrong the whole machine will stop, but it is so rarely that anything goes wrong that there are workshops now, filled with machines with hundreds of thousands of separate moving parts in them, which can be left for hours without a single workman. The machines go like a clock, making things all day.

That would be wonderful in any case, but it is almost incredible when we remember that thousands of parts in a single machine work in hundreds of different ways, at different angles, at different speeds, in different directions, though the motive power that drives them all is one and the same.

It is curious, if you think of it, that by turning a handle you should be able to turn one wheel round fast and another wheel round slowly; it is curious that you should be able to lift a very big thing with a very little thing. But achievements like this are the very commonplaces of machinery, and if you have a lifetime to spare, and want to make it interesting, one certain way is to study machines, and all the little parts of them—the long bits and the short bits, the thick bits and the thin bits, the sharp bits and the round bits, the cog-wheels and chains and flywheels, the pistons and pinions, the valves and discs, the cranks and shafts and connecting-rods, the grooves and screws and slots, the springs and blades and belts, the joints and nuts and flanges, the tubes and pawls and locks and spirals, and the thousand other things whose very names would frighten you when you began.

It all looks dull and terrible in a book, but once you are an engineer who really likes his work it is all as thrilling as "Robinson Crusoe," and the day may come when you will know all these queer things so well, when you will understand their meaning and realise their powers so well, that you will be able to take a few thousands of loads of iron ore, run the iron out of it like water, turn it into steel, and cut up the steel into thousands of parts, and bring them together in such a way, in all sorts of sizes and all sorts of shapes, and responding to all sorts of stresses and strains, that when your work is done you can put in a roll of paper at one end of your machine and this page will come out

printed at the other. Or you can put new sovereigns into it as they are made at the Mint, and the machine will test them, and put the good ones in one box and bad ones in another ; or you can put steel ribbons or wires in at one end, and the machine will make them into pins or pens, and count them, and pick them up for you. You can do miracles with a piece of iron if you are an engineer, and you can make a machine that will do miracles for you while you are busy with other things.

You can do wonders for yourself with any piece of iron, or with a stick. Try to lift a piece of stone with your hands, and perhaps it is too much for you, but take up an iron bar, push it under the stone, and you can turn the stone over with the help of the bar. The bar, that is to say, is multiplying your power for you. It will multiply it by two, or by four, or by eight, according to the length of it and the way you use it. This principle of the lever is in a thousand things. You cannot crack a nut with your hands, but let the power of your hands run along the arms of the nut-crackers ; you cannot row a boat with your hands, but let their power run along the oars. It is all a question of the lever, the principle that gives a child the power of a man, the principle by which the power of a man's arm is transferred to a piece of mechanism, and multiplied until it has almost no limit. This power works in every machine.

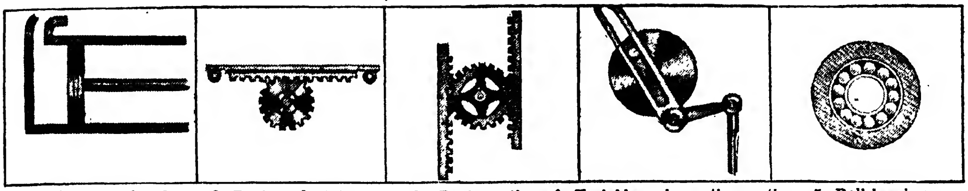
Here are some pictures of little things you will find in a machine. Think of what they do, and they will not seem such dull things to you. Look at the cam. It is only a little disc, but it is a slave at your command, not for one thing only, not always for the same thing ; the cam can be made to give to a machine any sort of movement you want. You have seen a connecting-rod working a pin, and perhaps the pin moves in a fixed circle. With the cam you can make the circle smaller or larger, or make the movements of the pin triangular or square or irregular to suit your end. A most original and useful thing is the cam.

And think of the clutch, so familiar to us all in these days. You can use it in thousands of mechanisms to start or stop a separate part while the machine as a whole is running : you start the engine of a motor-car, but the motor-car stands still ; you slip in the clutch, and the car is off.

We may think ourselves clever people, perhaps, but how many of us have ever had to think out the making of a joint for water-pipes which will turn in every possible way without a leak of water ? Yet somebody has thought out a wonderful thing like that. The ball bearings in a bicycle seem simple now, but the problem was not always so simple. In all machines the problem of friction is full of trouble, and it was a genius who realised that if he used small balls they would merely touch at points and wear out slowly, instead of touching along the whole surface and wearing out quickly.

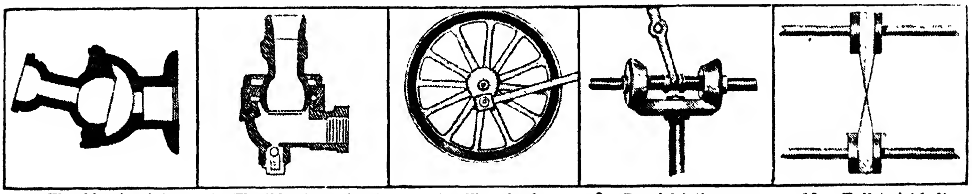
You have seen the steam-controlling governor of an engine, with the two little balls that fly round and rise and fall ; but perhaps you have not thought how marvellous they are, and yet how simple. An engine must have the steam it needs to drive it, enough, and no more, and with these balls the engine regulates its own supply. The balls fly round fast and rise, and as they rise they shut up part of a little opening to the steam supply. Flying round more slowly, the balls gradually fall, and so increase the opening and admit more steam.

The expansion joint, which gives a pipe room to expand with heat and yet prevents any leakage, is something you might be proud to have thought of ; so is that simple device that allows a shaft to revolve and drive another shaft at rapidly changing angles ; so are all these mechanical things which seem so small yet do so much, which seem so simple yet are really so miraculous. Men say a machine is dead, and dead it is in the sense that the most marvellous machine on earth cannot see or speak or hear or feel as a child ; but men have put a sort of mind in these things after all, and it is there for all who like to see.



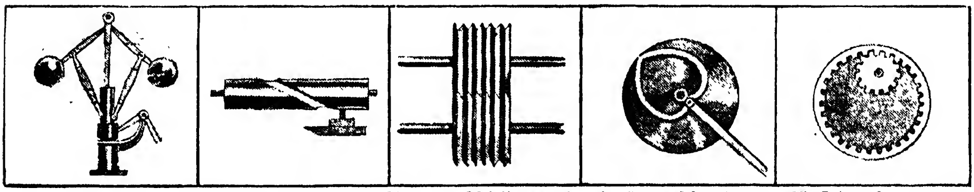
1. Piston and rod 2. Rack and pinion 3. Rack motion 4. Variable reciprocating motion 5. Ball bearings

1. This is the most familiar part of a steam-engine. Steam in the cylinder pushes the piston to and fro, and the piston-rod imparts the motion to a crank and mechanism outside. The steam enters and escapes through passages at each end of the cylinder. 2. The pinion imparts a straight-line movement to the rack, or the rack may impart circular motion to the pinion. 3. Used for opening and closing the sliding doors of valves. The pinion moves the racks up and down alternately. 4. A pin on the disc engages in a slot in the arm. As the disc revolves, the pin slides into positions in the slot at varying distances from the pivot on which the arm swings. The result is that the bell-crank and connecting-rod are moved at a quicker rate of return than when moving forwards. 5. Used for countless purposes in mechanisms. The balls rotate with the shaft. As they provide the contact of mere points, instead of the continuous surfaces of common bearings, the friction is very much less.



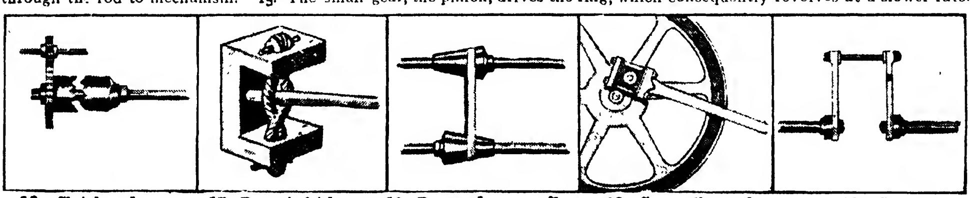
6. Flexible pipe joint 7. Flexible steam joint 8. Fly-wheel 9. Bevel friction gear 10. Full-twist belt

6. A joint between pipes that will turn in all directions and yet be watertight. The fitting is by spherical surfaces. The pipes are prevented from separating by a spherical flange which is a stuffing-box, being bolted to a flange on the hollow-ended pipe. These joints are used when pipes are laid on the bed of the sea. 7. Practically identical with No. 6. 8. Used chiefly on engines to equalise speed. The movements of a reciprocating piston and connecting-rod would be jerky if the fly-wheel were not fitted. The wheel corrects the variations in speed. 9. Bevel wheels without teeth, transmitting motion by the close contact of their smooth surfaces. The lower wheel drives the upper ones, only one of which is in contact at one time with the lower one, each being thrown in or out by the lever, or a clutch. The result is that the two upper wheels rotate their shafts in opposite directions. 10. When a belt is twisted thus, either shaft can rotate the other in an opposite direction.



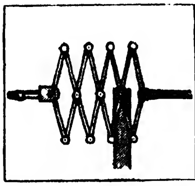
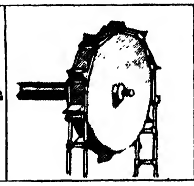
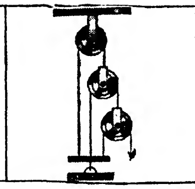
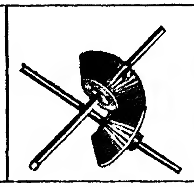
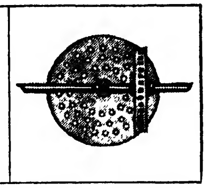
11. Governor 12. Grooved cylinder cam 13. Grooved friction gearing 14. Grooved heart cam 15. Internal spur gear

11. Used in connection with the steam supply of an engine. The speed of the rotating balls regulates the opening through which steam passes. The balls rise higher as speeds increase, and so reduces the opening to steam supply. As speeds are reduced, the balls sink and increase the area of the opening. 12. This imparts a straight-line motion to anything connected to it, by the pin moving in the cam groove. The length of the straight movement equals the length of the spiral groove cut in the cylinder. 13. Used on some light forms of hoisting machinery. One shaft drives the other through the close contact of the grooved surfaces of the wheels. The "V" form increases the frictional effects. 14. The disc is grooved heart-shape, and receives a pin which controls the connecting-rod. Two equal movements of rise and fall are produced and communicated through the rod to mechanism. 15. The small gear, the pinion, drives the ring, which consequently revolves at a slower rate.



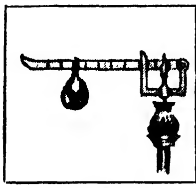
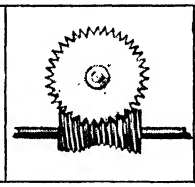
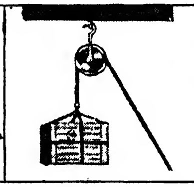
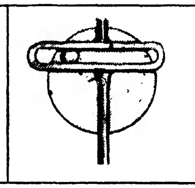
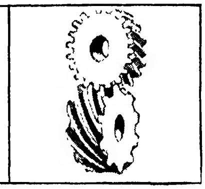
16. Clutch and gear 17. Rope twist lever 18. Reversed cone pulleys 19. Connecting-rod 20. Crank

16. Used in thousands of mechanisms to start and stop motions without stopping the machine. The gear on the upper shaft drives the gear on the lower one, but the lower gear runs loosely on its shaft, and does not drive it until the clutch at the right hand is pushed along to make its teeth engage with the teeth of the clutch on the lower gear. The clutch is able to drive because it slides on a key or feather in the shaft. 17. Shows that by twisting the rope with a lever it will become shortened and pull together the parts to which the rope is attached. 18. Belt-driving pulleys set in reverse positions on adjacent shafts. By shifting the belt as needed, a gradual increase or diminution of speeds is obtained, depending on the direction of movement. 19. Converts the straight-line motion of the piston-rod of an engine into the circular motion of the fly-wheel. The connecting-rod is pivoted at one end to the piseon-rod, and at the opposite end to a crank on the fly-wheel shaft. 20. The medium through which a connecting-rod imparts circular motion to a fly-wheel. The larger shaft below is that to which the wheel is attached; the smaller one above is that on which the connecting-rod swings. The form shown is a dip crank,

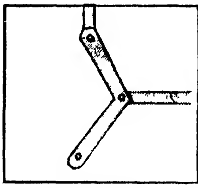
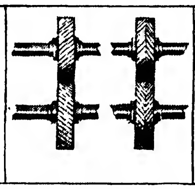
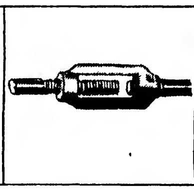
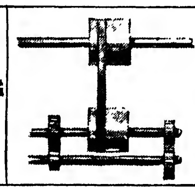
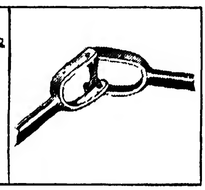
21. Lazy tongs movement **22. Link belt** **23. Multiple sheave blocks** **24 Oblique bevel gear** **25. Pin-wheel slotted pinion**

21. These close and open rapidly because the extremes receive the sum of the motions which take place at each angle, one angle being represented by the shading. 22. A series of iron links round a sprocket wheel. Used instead of leather belts, owing to the fact that they last longer. 23. A system of pulleys in which much power is gained with little range of movement. The end of each rope is attached to a bar, which carries the weight. The power increases with the number of movable pulleys. 24. Bevel wheels which connect shafts that cross each other. The teeth are not radial, but disposed askew. 25. Three different speeds of rotation are imparted to the pinion and its shaft from the three circles of pins round the face of the wheel. Either circle will engage with the holes in the pinion when the pinion is moved along into engagement with them.

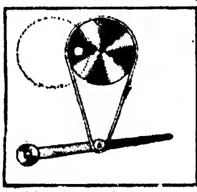
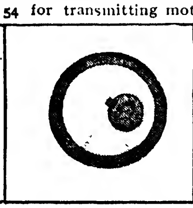
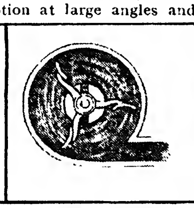
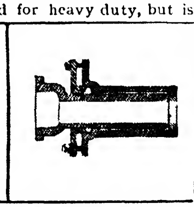
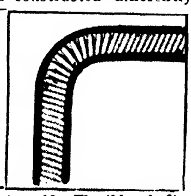
26. Safety valve **27. Hour-glass worm gear** **28. Sheave block** **29. Slotted yoke crank motion** **30. Spiral gearing**

26. A lever of the third order. The power exerted on the valve lies between the fulcrum and the weight. By the adjustment of the weight along the lever the pressure at which steam will open the valve is controlled. 27. The worm seen on the shaft turns its wheel precisely as the worm in No. 49 turns its wheel. But in the hour-glass worm gear the worm wraps round a large segment of the wheel, instead of being tangential to it as in No. 49, and is therefore more durable. 28. A lever of the first order, in which there is no mechanical gain, the pull on the rope being equal to the load lifted. Its one advantage is that the sheave changes the direction of motion so that the pull can be made in the most convenient direction. 29. Used in direct-action pumps. A method of producing a linear movement of a piston-rod from a disc without using a connecting-rod. The disc carries a pin, which, moving along the slot, reciprocates the rod. 30. Gear-wheels having teeth disposed angularly, the teeth forming short sections of long spirals. They drive shafts at various angles, depending on the dispositions of the teeth.

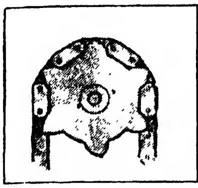
31. Toggle joint **32. Spiral toothed gearing** **33. Turn-buckle** **34. Two-speed gear** **35. Universal joint**

31. A joint which, as the arms which pivot on it are thrust more approximately to a straight line, exercises increased pressure at the ends of the arms. 32. Gear wheels with the teeth disposed angularly across the face. The teeth are short sections of long spirals. The first gear has single spiral teeth, the second one double spiral teeth. 33. Two rods are connected by the buckle, or loop, one turning in the buckle, the other screwed into it. By turning the buckle on the screw the rods are tightened or slackened. 34. Shows that, from the middle shaft, gears will drive the lower shaft at two different speeds, due to the difference in the diameters of the gears. Means are provided for putting either set of gears into or out of action. 35. Fulfils the same function as No. 54 for transmitting motion at large angles and for heavy duty, but is constructed differently.

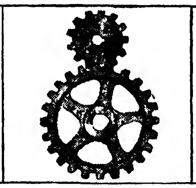






36. Eccentric crank **37. Eccentric wheel** **38. Fan blower** **39. Flanged expansion joint** **40. Flexible shaft**

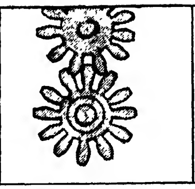
36. The pedal, being moved up and down, turns the eccentric crank through the cord. A shaft on which the crank is keyed drives the belt of a lathe. 37. A shaft passes through the disc in an eccentric position. The revolution of the shaft imparts a tumbling motion to the wheel, which, through the encircling band or strap, gives a definite reciprocal movement to a piece of mechanism, as a steam-engine valve. 38. Used for ventilating buildings and for producing blast for furnaces. The blades of the fan revolve in the casing. Air is drawn in through the sides and discharged through the pipe below. 39. When steam is conveyed through a length of piping, the expansion due to heat would distort and break the pipes if expansion joints were not fitted. One length of pipe is free to slide within the other as temperature varies. The small flanged piece, with its packing, is a gland for preventing leakage. 40. Shafts connected by a spiral spring. Used only for light service, as for portable drills, grinders, and the driving handles for telescopes; also by farmers for sheep-shearing and horse-clipping



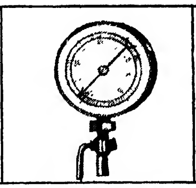
41. Sprocket wheel and chain



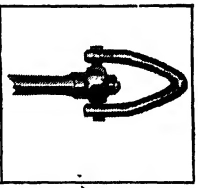
42. Spur gear



43. Spur gear

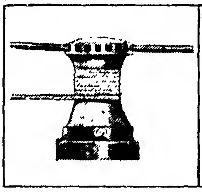


44. Steam gauge

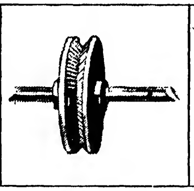


45. Swivel shackle

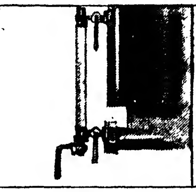
41. Flat link chain which fits over and between projections on the wheel. The wheel either drives or is driven. The chain does not slip, as a belt may, and is more powerful. 42. A wheel having teeth set at equal distances round the periphery. Engaging with wheels having similar teeth, but of various diameters, power is transmitted in machinery. 43. Used on wringing and mangling machines. Spur wheels with long teeth, so that they may engage at distances that vary slightly. 44. An instrument with a dial on which steam pressures in boilers are indicated by a pointer moving round the face, which is marked with figures. The pressure is taken by a spring within the gauge, and transferred to the pointer through gear-teeth. 45. A form of union which permits one portion to turn completely round the other, and also to assume angular relations.



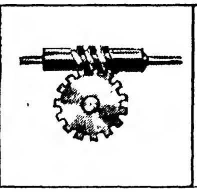
46. Vertical windlass



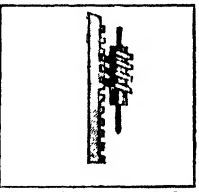
47. V-grooved pulley



48. Water gauge

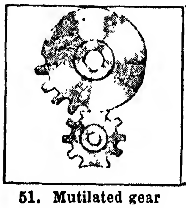


49. Worm gear

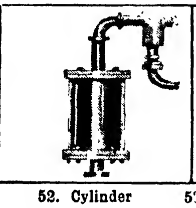


50. Worm screw rack

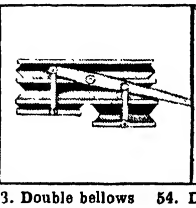
46. Also called a capstan. Turning the body by the capstan-bars winds the rope round it. It is locked by the pawl below. 47. The grooves, being "V'd" and roughened with serrations, exercise a greater grip on a rope than a smooth, hollow-faced pulley would do. 48. Indicates the height of water in a steam-boiler, the water rising to the same level in the glass tube as it does within the boiler. 49. An endless screw, the worm, drives the wheel, which has teeth inclined at the same angles as the screw-threads. 50. The worm drives a straight rack with inclined teeth, so producing linear motion.



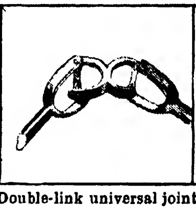
51. Mutilated gear



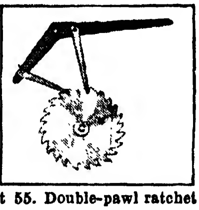
52. Cylinder



53. Double bellows

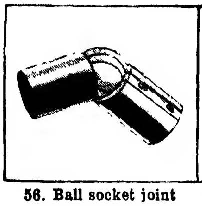


54. Double-link universal joint

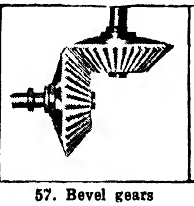


55. Double-pawl ratchet

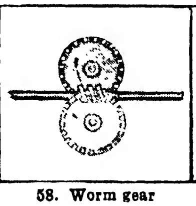
51. Many gear-wheels have some of their teeth cut away in order to produce intermittent motion. These are used in wheels and racks of many designs. 52. Used in engines of all kinds, pumps, and hydraulic machines. The preference for the cylinder, rather than for a square or other form, lies in the fact that it is easier to shape the interior accurately and the parts that fit the interior, pistons, and rods, than any other form. 53. Used for blowing organs. There are two blowing sections below, lifted and lowered alternately by the lever. The large upper section is provided for equalising air-pressure. 54. Used for transmitting motion at large angles and for heavy duty. Also termed Hooke's joint. It is similar to 35. 55 The two pawls, actuated by the lever above, impart a nearly continuous motion to the wheel.



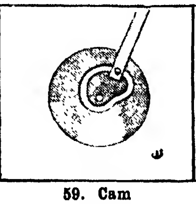
56. Ball socket joint



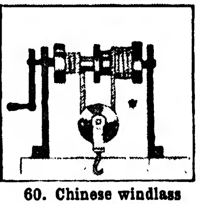
57. Bevel gears



58. Worm gear



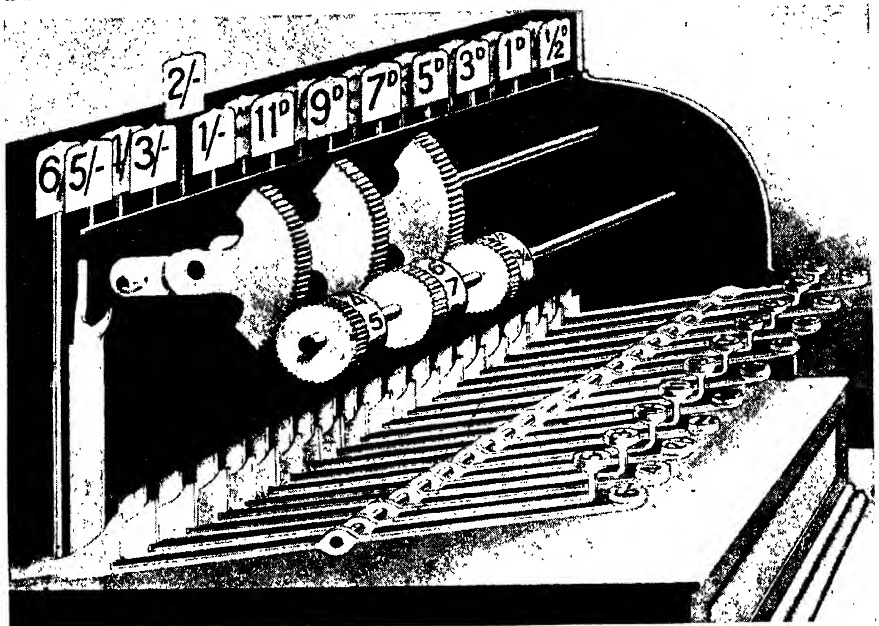
59. Cam



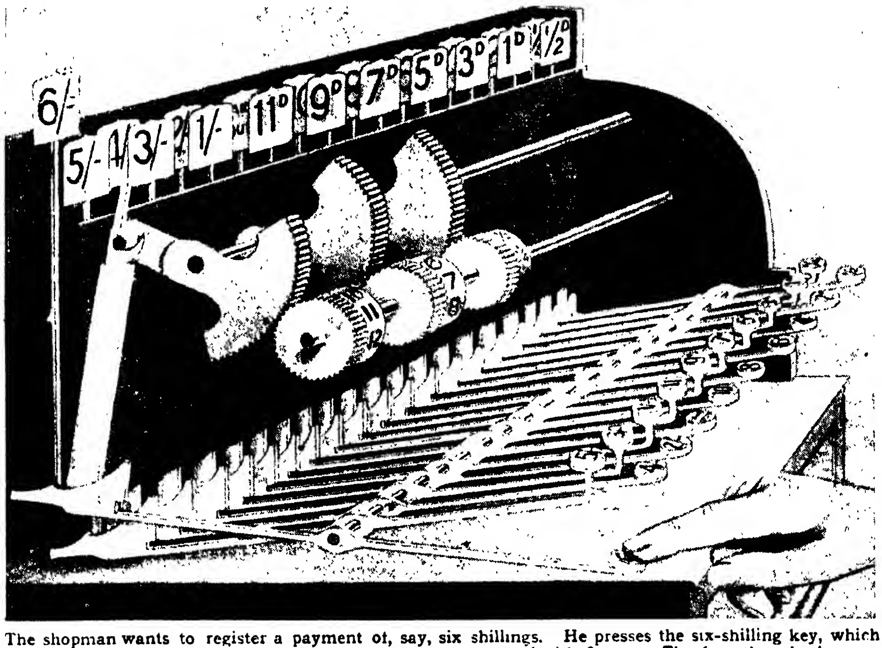
60. Chinese windlass

56. A device for allowing a shaft to revolve and drive another at various angles. The ball is made with grooves round it at right angles, and fits in hollowed-out ends of the shafts. Straps are fitted into the grooves and screwed into slots in the shaft to hold the ball in position. By this device the positions of the shafts of a machine can be changed without interfering with the driving. 57. These are cog-wheels, or toothed wheels, enabling one shaft to drive another at various angles. In the drawing the shafts are at a right angle, but gears can be made to drive shafts at almost any angles. 58. A method of rotating two shafts in opposite directions. A worm, or endless screw, on the horizontal shaft, rotates a wheel above with teeth on its side. Below, the endless screw is flanked by two wheels, with teeth facing each other. The result is that these lower wheels rotate their shaft in a direction opposite to the upper one. 59. One form of a mechanism which can be made to impart any movement of irregular outlines. In this case the disc has a recess cut in its face, or right through, in which a pin fastened to the end of the connecting-rod fits. The rotation of the disc gives an irregular movement to the rod corresponding with that of the recess in the disc. 60. An arrangement for lifting loads slowly. The rope is coiled round two cylinders, a larger and smaller, in opposite directions, so that when it unwinds from one cylinder it is being wound on the other. The difference in the size of the cylinders represents the power or speed gained or lost.

THE MACHINE THAT COUNTS UP MONEY



We all know those wonderful machines in shops, which register the amount of money we have paid for some article. These pictures show the principle upon which they work, though they are, of course, much more elaborate than here shown. Here the machine is at rest after registering a payment of two shillings.



The shopman wants to register a payment of, say, six shillings. He presses the six-shilling key, which raises a lever, and this moves a cogged arc which turns a wheel with figures. The 6 on the wheel comes into the right position, and at the same time an arm is raised with a ticket showing the amount paid. This remains up till another payment is registered by the shopman. There are separate wheels for shillings, pence, and farthings.

What was the Philosopher's Stone?

The philosopher's stone was something which the chemists of long ago were looking for. In those days they were called alchemists, alchemy being the old name for chemistry. They are the same words, *al* simply meaning *the.*

The general name of philosopher was given by other people to all who studied Nature in any of her aspects. The object of the search was to find something that would turn base metals into gold. This was really not worth aiming at, but in the search, which never succeeded, the alchemists found out all manner of chemical facts, for which we must always be indebted to them. And we must do them the justice to suppose that many of them were deeply interested in what they found out, for its own sake. The philosopher's stone would not have been worth finding for the sake of the gold, for directly gold became common it would lose its costliness. It has no real value in itself beyond that of a great many other metals. We are learning now that one metal can be turned into another, especially through the action of radium.

It is not certain that we shall be able to make gold for a long time yet, but radium already goes a very long way towards being what our ancestors looked for in the "philosopher's stone."

What was the Elixir of Life?

The old philosophers, or alchemists, sought, not only for the philosopher's stone, which should turn everything into gold, but also for an "elixir of life," which was certainly far more worth looking for. It was to be some wonderful draught which would prevent people from growing old. As everyone knows, they did not find what they wanted; but the question still remains whether we know more than they did on that subject.

In the first place, we shall not find anything which will prevent people from growing old at last. When men first found how to make spirits, they called the spirit *aqua vitæ*, or water of life; but that was a very bad mistake, and, indeed, there is no such thing to be found. It is reasonable to ask, however, whether most people do not grow old much sooner than they should, and die of some disease many years before they should have died of old age. Indeed, the real way to lengthen life, as someone has said, is to avoid shortening it, as most of us do. Though no "elixir of life" can be found, there is one simple rule we can all follow which will help us to lengthen our days, and this is to avoid all forms of alcohol, which our ancestors should have called the water of death.

What Use is Death to the World?

It is right to ask of any fact about living beings—What is its use? This really means, in what way is life served by the fact we are discussing? There is a use for life in every property of living beings. Anything that had not a use for life would soon disappear. Thus, we can discover the "survival value," as it is often called, of backbones, or green leaves, or red blood, or brains, or claws, or hunger, or sympathy; and we incline to believe that every fact about living beings serves life, or it would not exist.

Now, one of the constant facts about living beings is that, so far as this earth is concerned, they die, and the question is whether we can hope to find that this fact of death has a use for life. That would be a great discovery, for we are apt to think that death is useless and cruel.

Well, death certainly has a value for life—not for the life of the creature that dies, but for the lives of others. If there were no death there could be no parenthood and childhood, for plainly there would soon be no room for the introduction of new beings if those already there did not make room for them. Without parenthood and childhood, and all that they mean, no kind of life—human, animal, or vegetable—would be anything like what we know; and there would be no more progress, for that depends on new and higher kinds of life being born in the world. Thus, without death, mankind itself could never have been produced.

What Makes the Twilight?

A reader who has been to India asks why they had no twilight there. The explanation of twilight is this.

We say truly that light travels in straight lines, and therefore cannot go round a corner, yet we know equally well that light can be bent, and then, of course, it will go round a corner just as if it had been reflected from a mirror. This bending or breaking — called

refraction or back-breaking—of rays of light as they pass through the air is the explanation of twilight—which means between-light—in those parts of the world, such as our own, where it occurs. We notice that our twilight is sometimes shorter, sometimes longer; and this depends on the state of the air, especially as regards the amount of dust and of water in it. The bending of the sun's rays is often so great that we still see it above the horizon when it has really set. Where the air cannot bend the rays in this fashion, night falls suddenly in one black shadow.

Is Soft Water Good to Drink?

THERE are many kinds of soft water which are perfectly harmless to drink, but there is a certain amount of risk with some soft waters that have been exposed to lead. We call any water "soft" which makes an abundant lather with soap, and soft water is very nice to wash with for that reason. But there are kinds of soft water which, like rain-water, are good to wash with but, unlike rain-water, are not harmless to drink.

These are soft waters which have run a good distance through the soil, and have picked up from it some of the acid materials often formed in soil. When this happens, the soft water has the power of dissolving any lead with which it comes in contact by means of the acids in it, and so the water comes to contain salts of lead. To drink such water once or even a dozen times would not matter, but to drink it regularly would mean lead-poisoning, which is a very serious thing, and may cause death. The water supplied to our cities and towns is now excellent and free from this danger, but no other country is as well off as we are in this respect.

Why Do Children Ask Questions?

THE whole of the doing part of our nature depends, in the first place, upon a most important fact of our nature, which is that we possess instincts. All these instincts exist in order to serve our lives in one way or another, and their special business is to urge us to action. When we thus act under the influence of an instinct, we commonly have a certain kind of feeling or emotion, which corresponds with the instinct that is at work.

One of the most interesting and valuable of our instincts is curiosity. In the history of the long line of beings who have produced us, curiosity is a high instinct and one that is late in appearing. We do not find it among the lowest animals, but it is conspicuous in the highest kinds of monkeys.

The particular kind of feeling or emotion that goes with the instinct of curiosity is what we call wonder. Thus, when we ask a question of ourselves, we often say: "I wonder why" so-and-so. And this instinct grows, as mankind grows, from the most trivial curiosity about trivial things until it leads men to devote their whole lives to the discovery of the laws and wonders of Nature.

Children, therefore, ask questions because they are human, and because the possession of the instinct of curiosity and the feeling of wonder is a very great and worthy fact about the human race. Without it we should not be driven on to learn and to know, and without knowledge our place in the world would not be nearly so safe as it is. The trouble is that so many of us stop asking questions when we grow up.

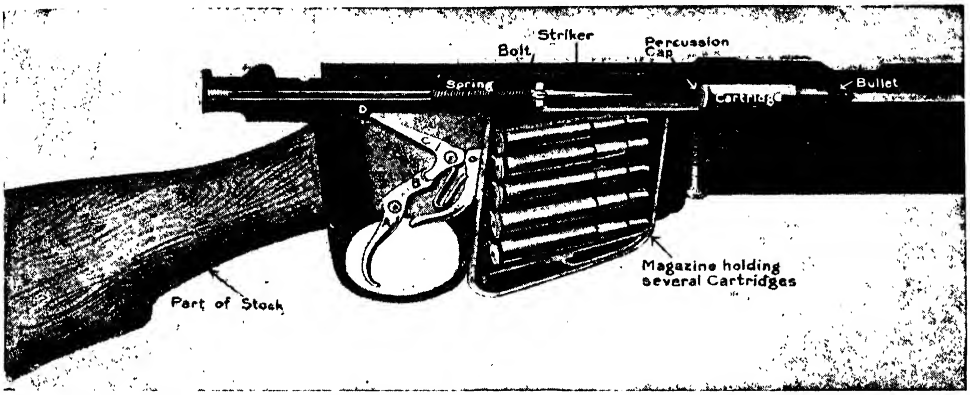
Have Animals Souls, and Where Do They Go When They Die?

IT has been believed by vast numbers of men that animals have souls. Especially in the great past civilisations of the East do we find this belief. Also it has often been supposed, not only that animals have souls, but that their souls represent stages, upward or downward, in the history of the souls of human beings. This is really the doctrine which is called "the transmigration of souls," and it explains, probably, why animals have so often been worshipped.

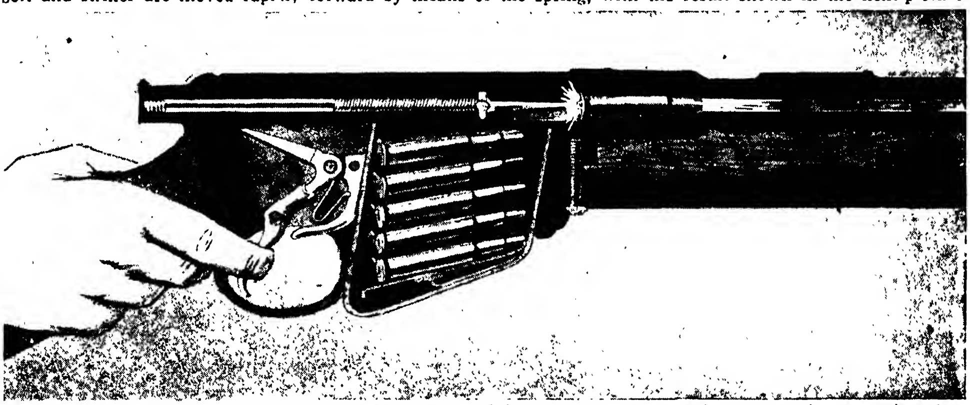
But though, perhaps, no one can be quite sure of the answer to this question, most thoughtful people find it hard to believe that animals have souls. If we believed this, we should find that it involved all sorts of difficulties, when we came to consider the case of humbler animals, and plants, and even tiny and trifling short-lived microbes.

Yet this does not mean that when even the humblest living creature dies anything is lost. We know that that would be quite opposed to Nature's universal rule that nothing is ever lost. On the contrary, the body which has been built up by the life of every living creature is valuable for the lives of other creatures. Not even the humblest life can be looked upon as useless.

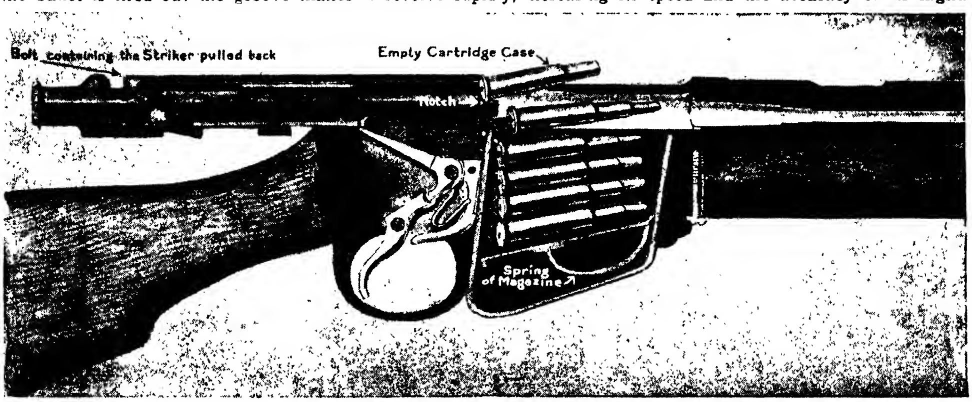
HOW A RIFLE FIRES TWELVE BULLETS



These pictures show how a rifle fires a number of bullets without being reloaded after each shot. The rifle is here set ready for firing. The needle point of the striker and the bolt are drawn back, and the cartridge which contains the bullet lies in its socket waiting for the striker to spring forward and strike the percussion cap in the cartridge. This is done by pulling the trigger, A, which lowers the elbow joint at B and pulls down the sear, or pivoted catch, C. This catch rests against the notch D, called the cocking piece, but so soon as it is lowered the bolt and striker are moved rapidly forward by means of the spring, with the result shown in the next picture.



The spring has now shot the bolt and striker forward, striking the percussion cap in the end of the cartridge just where we can see a spark or flash in the picture. This sets fire to the explosive in the cartridge, and the bullet is shot forward on its journey. There is a spiral groove inside the barrel of the rifle, into which the bullet fits, and as the bullet is fired out the groove makes it revolve rapidly, increasing its speed and the accuracy of its flight.



The shot is now fired, and the bolt, the outside of which is shown here, is drawn back by pulling the knob K. The brass rim of the cartridge case is caught in a little notch, marked in the picture, and as the bolt is pulled out it draws with it the empty cartridge case, and lets it fall without the necessity of touching it. The spring of the magazine, in which are a number of cartridges, now pushes another cartridge up into the line of the bolt, which, on being closed, fits the cartridge into place, and at the same time sets the trigger ready for the next shot

THE BOX THAT SPEAKS TO US

In a little room in London, with a row of ugly windows looking out on the dripping telegraph wires and the smoky roofs and chimneys of the City Road, is gathered a company of people. One is the great singer, Madame Melba; another is the celebrated violinist, Herr Kubelik; a third is the famous accompanist, Mr. Landon Ronald.

One of the walls of this room is a partition of wood and frosted glass. In the centre of it a brass trumpet projects into the room. Close to this trumpet there is a tall stage of rough wood, and on this stage stands a cottage piano.

Mr. Landon Ronald climbs to the stage and seats himself before the piano. Kubelik places his violin under his chin; Madame Melba stands in front of the trumpet. All conversation ceases. Everybody is very still. Then a bell rings.

Mr. Ronald begins to play the piano. In a moment Madame Melba is singing. Presently the violin of Kubelik sends its glorious tones mingling with the voice and the piano. What is happening?

All these *movements*—the movement of Melba's lips and throat, the movement of Mr. Ronald's hands, the movements of Kubelik's bow—are passing from this little room in the City of London into the distant ages of the future. The people in the room hear them, but it is only for a swift moment; they rush on, like an arrow, like a train flying through the country, away from To-day, away from the Present, into the invisible and unknown world of Tomorrow and For Ever.

These movements of which we have spoken have an effect upon the atmosphere. If a person sweeps a fan in front of our face, we feel on the skin a motion of the air. The movement of the lips has an identical effect; they set up a motion in the air, they make the air vibrate. When Melba's lips form the word "Home," they send not that printed word into our ears, but only vibrations of the air, vibrations of sound; and in our own minds we convert these vibrations of sound into the word "Home."

And now today all the vibrations of sound made by the singer's voice, the violin, and the piano mingle in one continuous and varying undulation, enter the brass trumpet, as well as the ears of the little listening company; and the trumpet receives on the other side of the partition a force of sound which moves a silver needle exactly as the vibrations move the drum of the ear. The little silver needle at the end of the brass trumpet moves with the waves of air, and its movements are the movements of a writer. That needle is the secretary of posterity. It is writing down the song for people not yet born—people who will live in five hundred or a thousand years. If there had been gramophones in the earliest ages, we might now listen to the movement of Homer's lips, and hear the passionate cry of John the Baptist: "Repent, for the kingdom of heaven is at hand!"

Under the silver needle there is a revolving plate made of some wax-like composition, which receives in almost invisible lines the pressure of the needle's point. When the song is finished, or the needle ceases to move, the plate is taken from under the needle, and carried to skilful workmen, who copy the spider lines of the needle on a diagram of metal. This metal diagram is the master-record; from this may be made as many copies as are needed. In a thousand years' time men and women will pay to get copies of it.

When the song which the people listen to in the City Road, this foggy morning, has been *transferred*—think of it!—from the composition plate to the metal diagram, and conveyed from the metal diagram to the vulcanite record which we may buy for a few shillings—it will be placed, in all the cities of the world and down all the ages yet to be, on the machine called a gramophone, and will be reproduced exactly as it was sung.

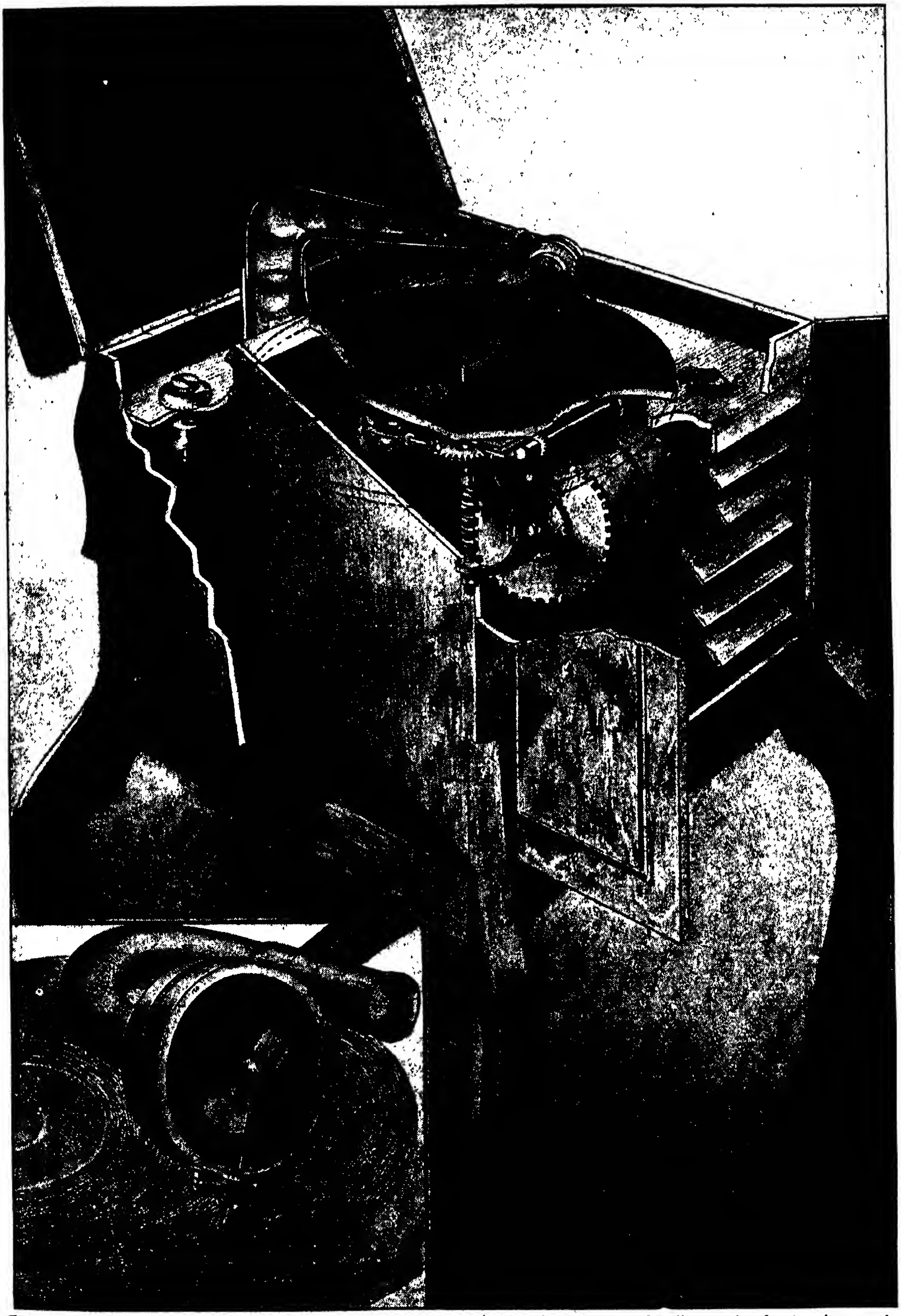
A little needle will pass over the disc as it revolves on this machine, the scratches on the disc will set the needle vibrating, the vibrations will strike upon the tiny mechanism just above the needle called the voice-box or sound-box, and, leaving the sound-box, these vibrations will issue from the trumpet as the very song sung in the City Road.

Words will come from the trumpet!

The wonder of this fact is overwhelming to our understanding. It is a miracle. How is it that the dead mechanism of that simple sound-box converts these vibrations, these little hurried jerks of the needle, not merely into sounds, but into actual *words?*

It is a thing that no man knows.

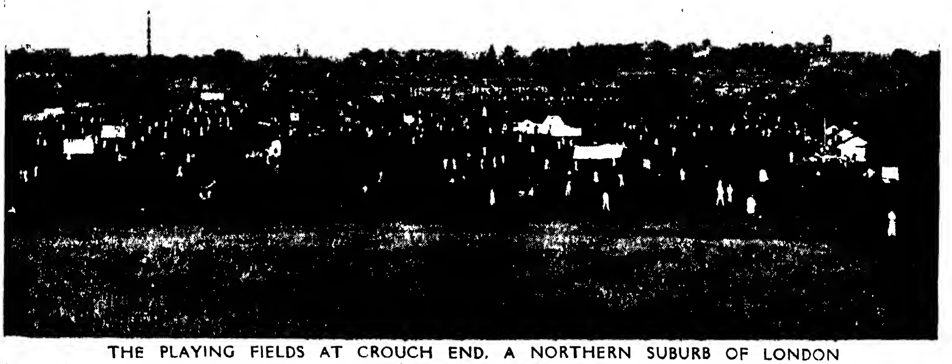
HOW DEAD MACHINE UTTERS HUMAN VOICE



This picture shows the gramophone talking. A needle moves in the zigzag curve of a disc made of vulcanite; as the needle vibrates it shakes a glass disc and sends into the trumpet waves of air corresponding to the sounds of words.

THE PLAYING FIELDS OF LONDON TOWN

CRICKET AT ST. QUINTIN PARK, IN THE WEST OF LONDON



THE PLAYING FIELDS AT CROUCH END, A NORTHERN SUBURB OF LONDON

ON THE FRINGE OF LONDON—CRICKET AT MOTTINGHAM, NEAR ELTHAM

The photographs on these pages are by courtesy of the London Playing Fields Association and Gordon Smith.

HOW CRICKET BECAME KING
THE OUTDOOR GAME OF ENGLAND

It seems strange that that most gentlemanly and inoffensive of outdoor pastimes, cricket, which has been called "the king of English games," should once have been regarded with fear and trembling as the forerunner of revolution and national decay.

Yet such was the case, for in the middle of the eighteenth century, when cricket was beginning to become the great national game, there were many who foretold disaster as the result of its growing popularity. The mingling together in friendly play of men of various ranks and classes was regarded as being opposed to all discipline and social order. One newspaper spoke of the shock caused by seeing a shoemaker playing against a member of Parliament, and asked, "Would it not be extremely odd to see lords and gentlemen, clergymen and lawyers, associating thus with butchers and cobblers in pursuit of these diversions?"

"A journeyman shoemaker," the paper declared, "may play from five o'clock on Saturday, in the afternoon, till it is dark, *at skittles*, provided he has worked all the rest of the week," but it suggested that games suited to "gentlemen" and people of fashion, "whose time may be, indeed, of very little value," are not at all fitted for commoner men who work for their living. "It propagates a spirit of idleness," said the paper, "at a juncture when, with the utmost industry, our debts, taxes, and decay of trade will scarce allow us to get bread." This was certainly very queer advice, seeing that at that time most of the taxes were paid by the working classes.

There was more reason for complaining of the way in which the first-class matches drew large crowds of spectators, who might have been more profitably employed, either in playing themselves, or in other pursuits. One writer declared that though noblemen, gentlemen, and clergymen might divert themselves as they thought fit, and associate with butchers, cobblers, and tinkers, he doubted very much whether they had any right to invite thousands of people to be spectators of their agility, for it drew numbers of persons from their employment, to the ruin of their families.

Those early matches, too, used to be played for large wagers, and, in so far as this feature was the cause of the opposition, we must sympathise with the objectors; but it is clear that the main ground of opposition to cricket was the way in which men of the upper and educated classes mixed on a friendly and equal footing in the matches with labourers and small tradesmen.

Of course, we now know that this friendly mingling of men of all ranks is of great advantage to the men themselves, no matter what class they may belong to, but it took more than a century to find this out. One of the fine things about cricket is that it brings together, as no other game will, the members of a working men's club and those of some aristocratic body, like a university, the boys of an elementary school in a poor district of the city or town and the boys of a high-class grammar school.

Though the game in anything like its present form is not more than three or four hundred years old, its origin can undoubtedly be traced back to the primitive times when men lived the simple life in the open air. The first cricket ball was, no doubt, a stone, the bat a natural stick, and the first wicket a tree. Some youth minding his father's sheep would find time hanging heavily on his hands, and, picking up a stone, would try to hit a tree with it. Practice would make perfect, and a friend or two standing by would watch him. Then, possibly, one of these would pick up a broken branch and undertake to defend the tree; and from time to time he would strike the stone, which a bystander would catch when it came his way, and toss back to the original thrower. In some such play, no doubt, we find the beginning of cricket.

The various games of club and ball played by the Saxons and Normans all led up to cricket, which is as much the result of evolution as are the players themselves. The earliest known reference to the game by name is in the accounts of King Edward I., who is charged a certain sum for the pastimes of his son, the Prince of Wales, afterwards Edward II. In these accounts a game called "creag" is mentioned, which is supposed to refer to cricket.

A LETTER THAT TRAVELLED A HUNDRED MILES AN HOUR IN A CRICKET BALL

The game, however, was not very popular, and it is curious that no mention is made of it by Shakespeare or by any other dramatist of his time, although they mention many other popular games.

In the eighteenth century what had been merely a village pastime was taken up by noblemen, and soon became popular and fashionable, so that a poet wrote, in 1770:

Hail, cricket! glorious, manly British game!
First of all sports, be first alike in fame.

Perhaps nothing did so much to make cricket fashionable as the patronage of successive Princes of Wales, and one of these, Frederick, the son of George II., died from the results of a blow from a cricket ball. George IV. also was a great patron of cricket.

An amusing story is told of this period. In 1753 Lord March laid a wager with another peer that he would send a letter a distance of a hundred miles in an hour. He then arranged with a number of cricketers, who were expert fielders, to stand in a large circle. The letter was enclosed in a cricket ball, and the men threw the ball from one to the other, round and round the circle. At the end of an hour the circle was measured, multiplied by the number of times the ball had gone round, and the result was 120 miles!

THE OLD CRICKETERS WHO PLAYED WITH A SKIN BALL AND TWO STUMPS

When cricket became the great national pastime, soldiers were, by an order of the Horse Guards, provided with cricket grounds adjoining their barracks, and all the warships had bats and balls supplied to them.

The greatest impetus given to cricket was by the invention and spread of railways, which made it possible for teams to visit and play in different parts of the country, thus greatly increasing the interest in the game.

Not only cricket itself, but the bat, ball, and stumps have changed in the gradual evolution of the game. There were at first only two stumps, wide apart, with a single cross-piece. But when, during a match in 1775, the ball passed several times between the two stumps without touching either, it was decided to add a third stump in the middle, and to use two bales instead of one single cross-piece. The bat, from being a mere club, came to assume the shape of a gardener's budding-knife, but this gradually gave way to the present form. Up to 1745 the bat might be of any size or shape the player liked, but this liberty was carried to such an absurd extreme that some players used a bat so wide that it completely hid the wicket from the bowler's view. A limit of size was therefore fixed, and it became the custom to have an iron frame on every first-class ground in which to place the bats, and test their size before playing.

The primitive balls of wood were soon covered with skin. These gave way to the all-leather ball, and now balls are made of cork and yarn, covered with a thick cowhide. Runs used to be called notches, because the score was first of all kept by cutting notches on a stick. The grounds, too, have been greatly improved, and the heavy scoring of the present day is largely due to the fact that the pitches are almost as smooth and even as billiard tables.

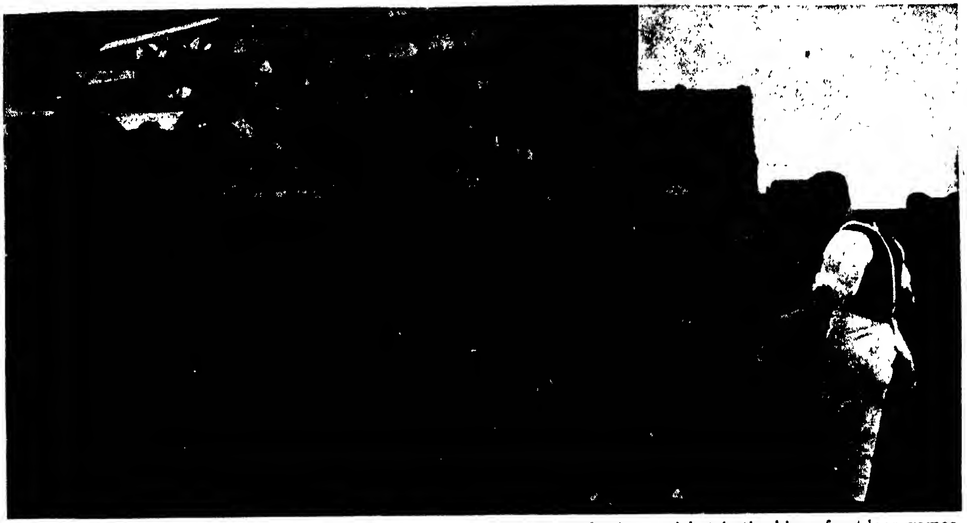
HOW BOWLING BEGAN WITH A LADY THROWING A BALL IN A BARN

The whole business of providing the cricket outfit is now a very great industry, from the growing of the willow-trees to the making of the bats, balls, and stumps, and the keeping in order of the pitches.

The present system of bowling, curiously enough, is due to a lady. It was introduced by a cricketer named Wills, who first got the idea through seeing his sister throw a ball in this way while playing cricket in a barn. Ladies have always had a wistful interest in the game.

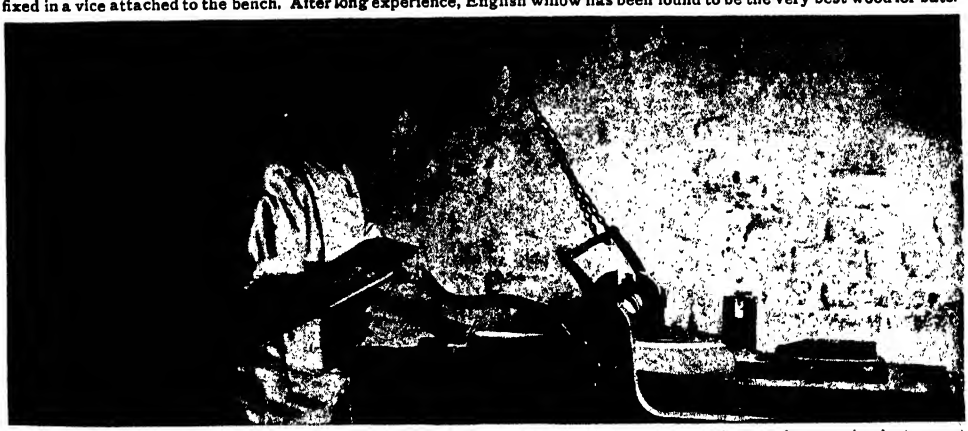
Cricket is essentially an English game, and foreigners often have great difficulty in understanding where the amusement comes in. When Ibrahim Pacha, the Viceroy of Egypt, visited this country, among other entertainments provided for him was a first-class cricket match at Lord's. It is said that after looking wearily for two hours at the exertions of the players, he sent a message to the captains stating that, although he did not wish to hurry them, he would be glad if, when they had tired themselves by running about, they would begin the game. He did not know how much of the health and vigour of the English nation has come from this game which began with a stone, and a stick, and a tree.

THE VERY BEGINNING OF A CRICKET BAT



The making of cricket bats and balls is an important industry in England, where cricket is the king of outdoor games. Thousands of willow-trees are grown for making bats, and here we see the rough-hewn blades of the bats being seasoned.

The blades are roughly shaped with a tool called a spoke-shave, which the man in this picture is using, the wood being fixed in a vice attached to the bench. After long experience, English willow has been found to be the very best wood for bats.



When the blades have been shaped almost to the true proportions by cutting, they are passed through a pressing instrument, as shown here, which makes them more accurate and strengthens the texture of the wood. They are then ready for the handles.

SHAPING THE HANDLE OF A CRICKET BAT

Cricket bats were at first made in one piece, then the handles were made of ash, and now they are of cane. The man on the left is making the handle, and the one on the right is cutting the splice in the blade in which to insert this handle.

The left-hand picture shows the cane handle being driven firmly into the blade, before it is finally shaped. In the picture on the right the man is making the handle round, the angles being cut away gradually by means of a small spoke-shave.

The pictures in these pages were taken at the well-known factories of Messrs. John Wisden and Co. at Stratford and Tonbridge.

STRINGING THE HANDLE OF A CRICKET BAT

After the handle of the bat has been more or less cut to the shape which it should have, it is placed in a lathe and turned till the roundness is perfect. In this picture the mistiness of the bat is caused by its rapid whirling as it turns in the lathe.

In modern first-class cricket the weight of the bat has to be about two pounds, six ounces ; so that an important part of the manufacture of cricket bats is the adjusting of the weight and balance, which is being done here by cutting away the wood.

When the woodwork of the bat is properly shaped and finished it is placed in a lathe, and the handle is bound round tightly with many yards of waxed string to hold the sections of cane together and more firmly fix the handle in the blade.

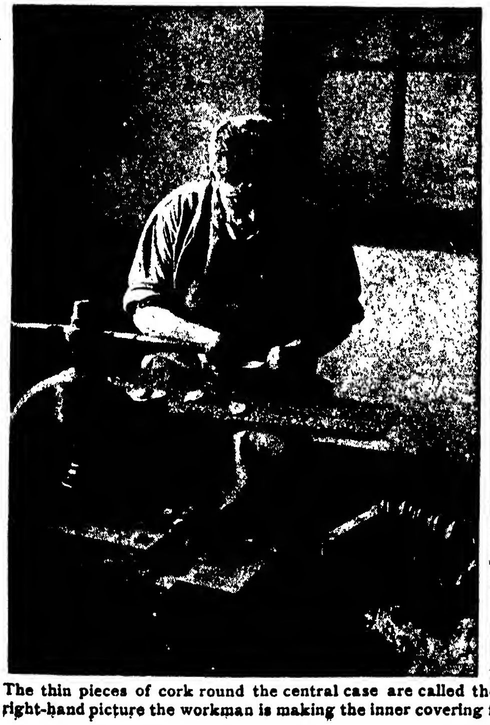
WHAT A CRICKET BALL IS MADE OF

In the very early days of cricket almost any kind of ball was used, but now the ball has to be very carefully made of cork and twine and leather. Here we see the raw material at Messrs. Wisden's factory. The leather is being cut into strips.

The cricket balls are always covered with red leather, and in the left-hand picture the leather is being dyed, while on the right the workman is cutting a large piece of cork into thin strips to pack round the central core of cork in the ball.

THE BUILDING UP OF A CRICKET BALL

The cricket ball is built up round a cube of cork, the twine and thin layers of cork being added until the ball is of the required size and weight. This man is sewing together the pieces which will make the inner covering of the ball.



The thin pieces of cork round the central case are called the quilt, and on the left we see the quilt being made. In the right-hand picture the workman is making the inner covering for the ball, the parts being held in position by a shaped vice.

THE BALL IS READY TO FLY THROUGH THE AIR

Many yards of hemp-twine are bound round the cork of the ball to hold it together, and to give it lightness and spring. The winding is done by hand, and the men get very expert at the business, working rapidly as they cover ball after ball.

When the inner part of the ball is completely bound, it is put in a vice and squeezed to the proper shape, as shown on the left, and then the outer covering of red leather is sewn on, as seen in the right-hand picture, when the ball is ready for play.

HOW WE GET OIL

THE GREAT MODERN POWER AS OLD AS BABYLON

We do not know who was the first man to strike oil, but we know that he lived thousands of years ago, for we know that oil from the earth—petroleum means simply "rock-oil"—has been used for at least three thousand years.

Oil, we are told, is the great modern source of power, but it is at least as old as the Tower of Babel. The "slime" spoken of in the Old Testament as being used for mortar in the building of the tower was petroleum, and Herodotus speaks of the oil-pits in the plains of Babylon. The explorers of the ruins of Nineveh have found the remains of mineral oil used as cement in the brick buildings of the Assyrian capital. The Spaniards, too, when they went to America, found oil-pits lined with timber, which had been dug, not by the natives then living in the New World, but by some earlier race that had lived and died long before Columbus ever thought of sailing away to the setting sun.

Oil from the petroleum springs of Sicily was being used in the lamps that lighted the temple of Jupiter in Rome when Jesus was born at Bethlehem, and this is the earliest definite record we have in history of paraffin being used for illuminating purposes. But the Persians and other Eastern nations had probably used it for both heat and light centuries before. These ancient peoples, however, tapped only the oil that lay near the surface of the ground; they knew nothing of the great lakes of oil hidden deep down in the earth's crust.

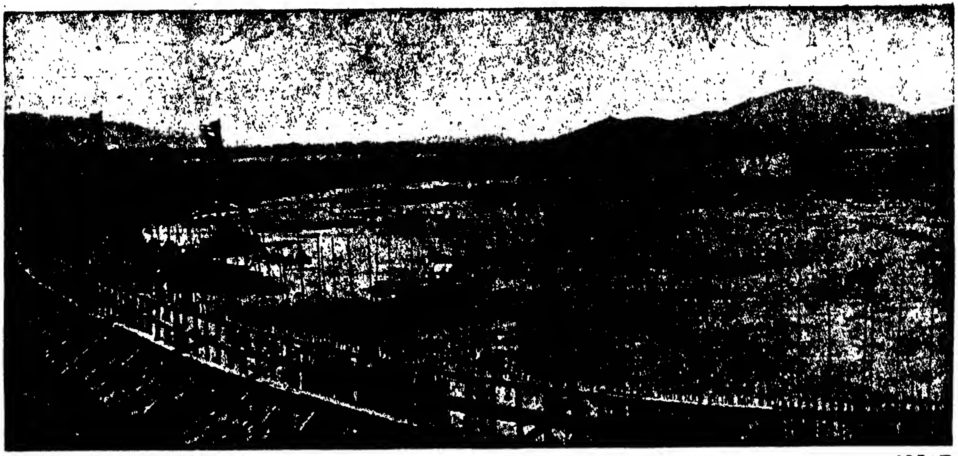
It is in modern times, and even within the last hundred years, that the rise of oil as one of the world's most important commercial products has come about. There are few things more valuable today. And yet the keen business men who first found the vast stores of petroleum hidden in the earth did not want oil, and were only too glad to see it run away in the creeks and river-beds. Some of them, however, lived to learn that they had watched a fortune run to waste. And if they could have lived to see this day, they would have found oil so precious that when a piece of good fortune falls to a man we say he has "struck oil."

In the early part of the nineteenth century the men boring artesian wells in America, to get at the brine for their salt-works, struck oil unexpectedly, and were very disgusted because the oil mixed with their brine and spoilt it. The annoyance, however, soon changed to alarm, for in 1829 a salt-well drilled in Kentucky tapped a great reservoir of oil, which poured out, caught fire, and set a river in a fearful blaze over a stretch of fifty miles. Such a sight had never been seen before, and, although the fire was put out at last, the oil continued to run away for many years.

At last somebody thought of collecting a little of the oil in small bottles, which he sold as American Medical Oil. Vaseline, which is made from petroleum, is valuable as an ointment, and probably there was some healing value even in the crude petroleum, for the bottles seem to have paid, and before long other men were selling the oil in bottles under fancy names. But nobody appears to have thought that mineral oil could be of any other use—least of all for lighting purposes. The smell was so objectionable that it was almost impossible to burn it indoors.

Then a strange thing happened, about the middle of the nineteenth century, which set men to work studying oil. The whale-fishers who came back from the northern seas returned year after year with the news that whales were getting scarce, and were likely soon to be extinct. As most of the oil used for lighting came from whales, people began to get alarmed as to what would happen on long winter evenings. So men of science made experiments, first with the oil from the shale in coal-mines, and they were able to distil from this a very good illuminant, which they called kerosene, because it could be made into a solid wax, and kerosene is from the Greek word for wax. At once a big industry sprang up in preparing shale oil; but the success in this direction set other scientists at work, and they were soon able to refine the crude petroleum itself, of which vast quantities were discovered in America.

The most successful oil company that has ever been formed, and the most wonderful business organisation that the world has ever seen, is that which controls the oil industry in America and practically everywhere. It has made profits so fabulous that it sounds like a dream. Yet the first oil company was a failure. It was started in America in 1854, by two lawyers, and was

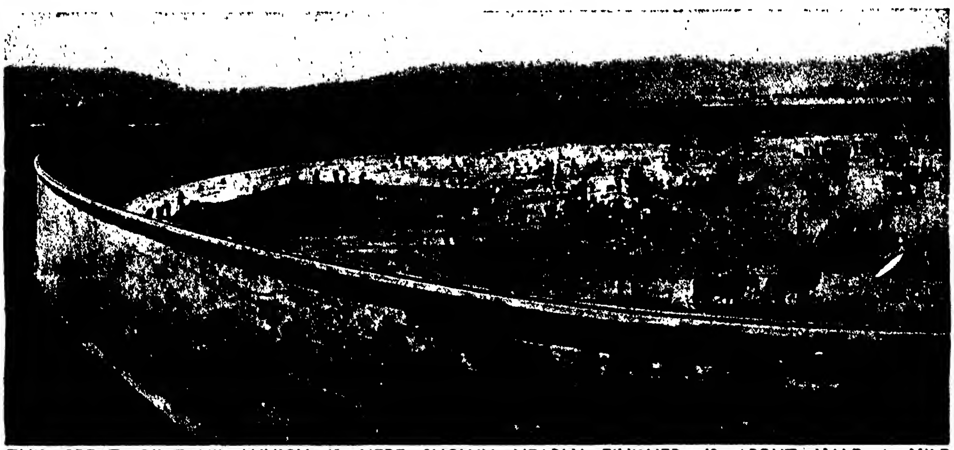


MAKING AN IMMENSE TANK OF CONCRETE TO HOLD 42.000 000 GALLONS OF OIL. TO BUILD THIS GREAT

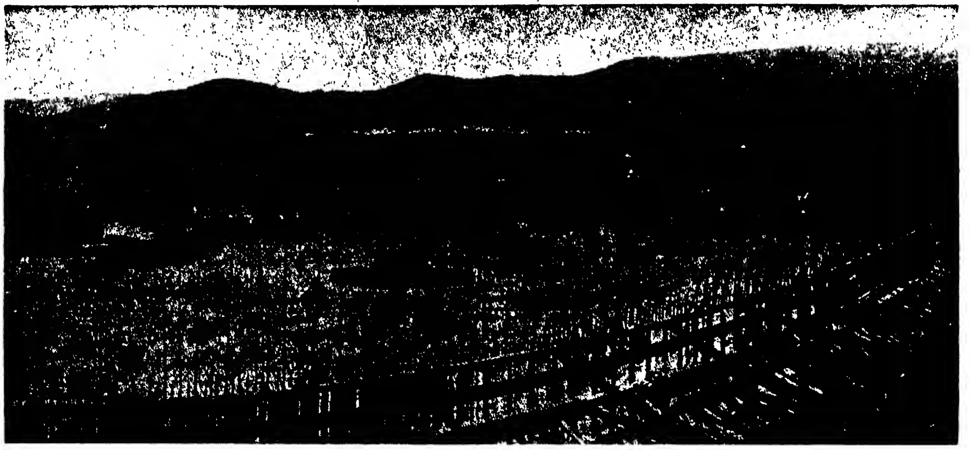
taken over as a failure by another company. Still the business would not succeed, until in December, 1859, a Colonel Drake, amid great difficulties, and in spite of much opposition, bored the first artesian well ever sunk for tapping oil. It reached a depth of 70 feet, and then the oil was struck, rising in the pipe to within 10 feet of the surface. Pumps were set up, and forty barrels of oil a day were drawn out, equal to 1680 gallons, and realised an income of £160 a day.

This was considered marvellous, and the news spread like wildfire. There was intense excitement throughout the United States, and even in other countries. Hundreds of wells were sunk in a few weeks, and there was a rush to the oil-fields of Pennsylvania like the rush to California when gold was discovered there in 1849. Many of the wells proved to be dry, and their promoters lost everything; but in most cases this was because the wells had not been sunk deep enough, and years after, when the wells were driven lower, a rich yield of oil was the result.

Up to 1861 the wells were not very deep, and pumps had always to be used to bring up the oil. But in that year a great well was sunk, 400 feet deep, and, for the first time, the oil gushed out of its own accord. Deep wells were then sunk everywhere, and in many cases the oil spouted out vast rivers of petroleum at the rate of over a hundred thousand gallons a day. Much of this was lost, but the supply was now so immense, especially as oil had been struck in other places, that the supply far exceeded the demand. The price of oil fell lower than it had ever been before or has ever been since, and the owners of the oil-fields came to an



THIS GREAT OIL-TANK, WHICH IS HERE SHOWN NEARLY FINISHED, IS ABOUT HALF A MILE

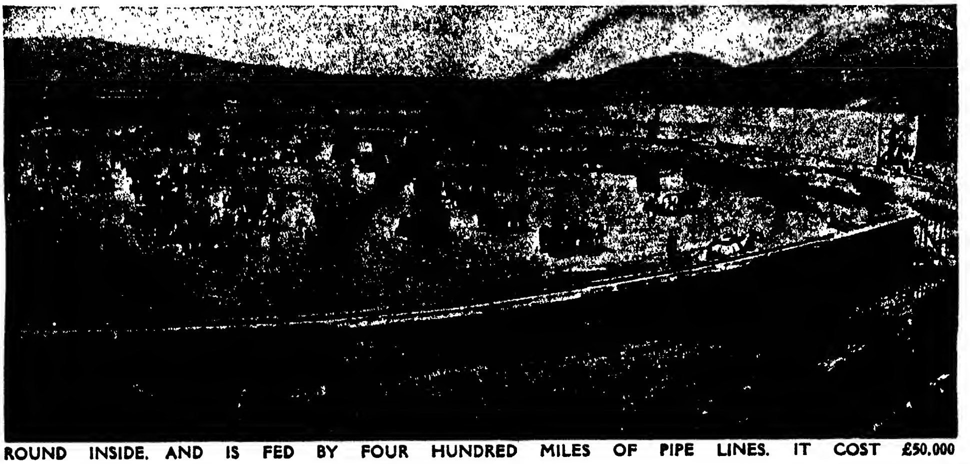


RESERVOIR SIX HUNDRED MEN AND SIX HUNDRED HORSES WERE ENGAGED FOR MANY MONTHS

agreement to restrict the output. By doing this they were able in a year and a half to reduce their huge stock of nearly fourteen hundred million gallons by about a half, and the price then gradually rose, and, as the control of most of the industry throughout the world is centred in a few hands, the market is now completely regulated. The coming of the motor-car, for which mineral oil is the motive power, has done more than anything else to send up the value of petroleum, and in 1912 it nearly doubled in price.

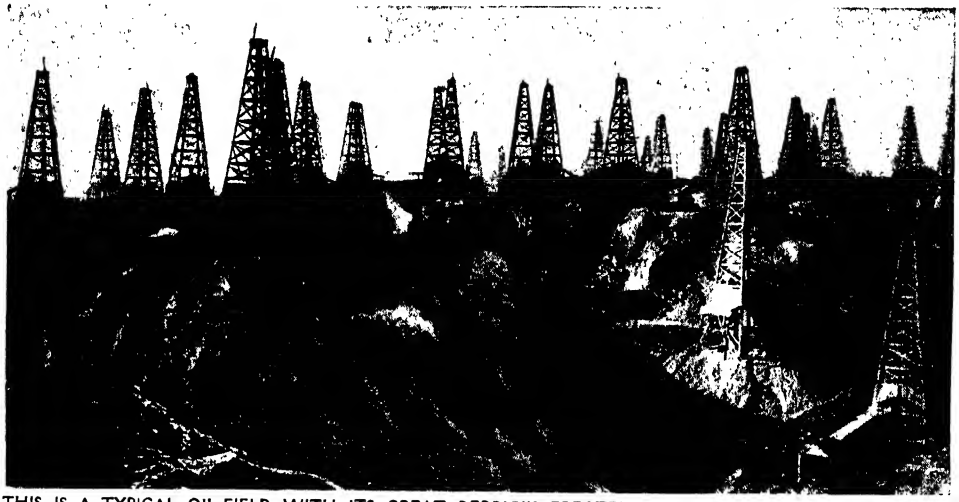
The supply of oil that the earth yields is almost fabulous. A recent year's figures show that the annual production of petroleum is nearly ten thousand million gallons, the value of which is about £200,000,000, and of this supply one half is produced in America alone. If it were all put together it would form a great sea of oil big enough to float a fleet in. These figures are all the more amazing when we remember that less than a hundred years ago oil was allowed to run to waste, and the men who struck it thought it a great nuisance.

How the oil came to be in the earth is difficult to say. It used to be thought that it was formed in the rocks by the decomposition of animal and vegetable matter ; but, as it exists in large quantities in rocks containing little evidence of animal and vegetable life, it is now thought that the oil was distilled by the chemical action of the minerals in ages past, somewhat in the same way as we are able to distil oil from the shale. Whichever is the true explanation, it is only another instance of how Nature in the past has bountifully provided for the needs of man.

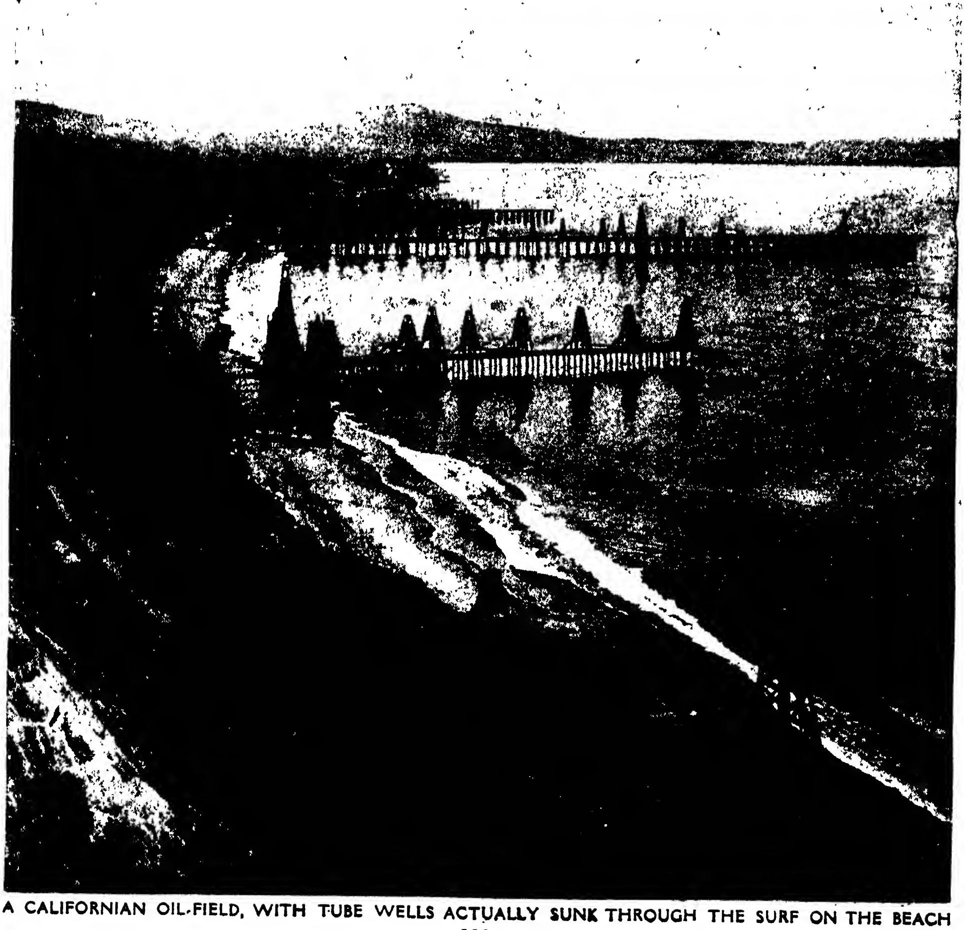


ROUND INSIDE, AND IS FED BY FOUR HUNDRED MILES OF PIPE LINES. IT COST £50,000

WHAT A GREAT OIL-FIELD LOOKS LIKE

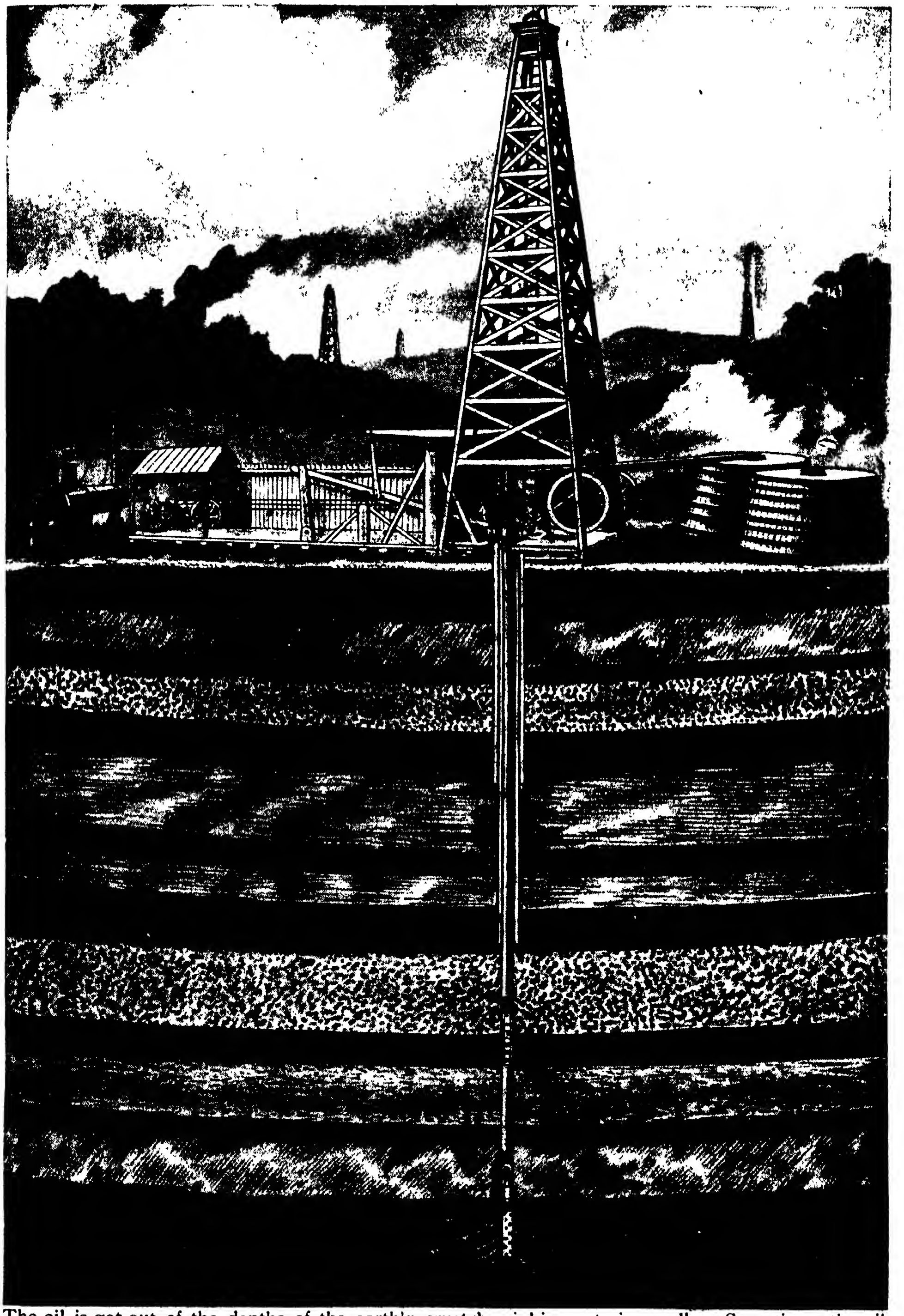


THIS IS A TYPICAL OIL-FIELD, WITH ITS GREAT DERRICKS ERECTED FOR THE BORING OF THE WELLS



A CALIFORNIAN OIL-FIELD, WITH TUBE WELLS ACTUALLY SUNK THROUGH THE SURF ON THE BEACH

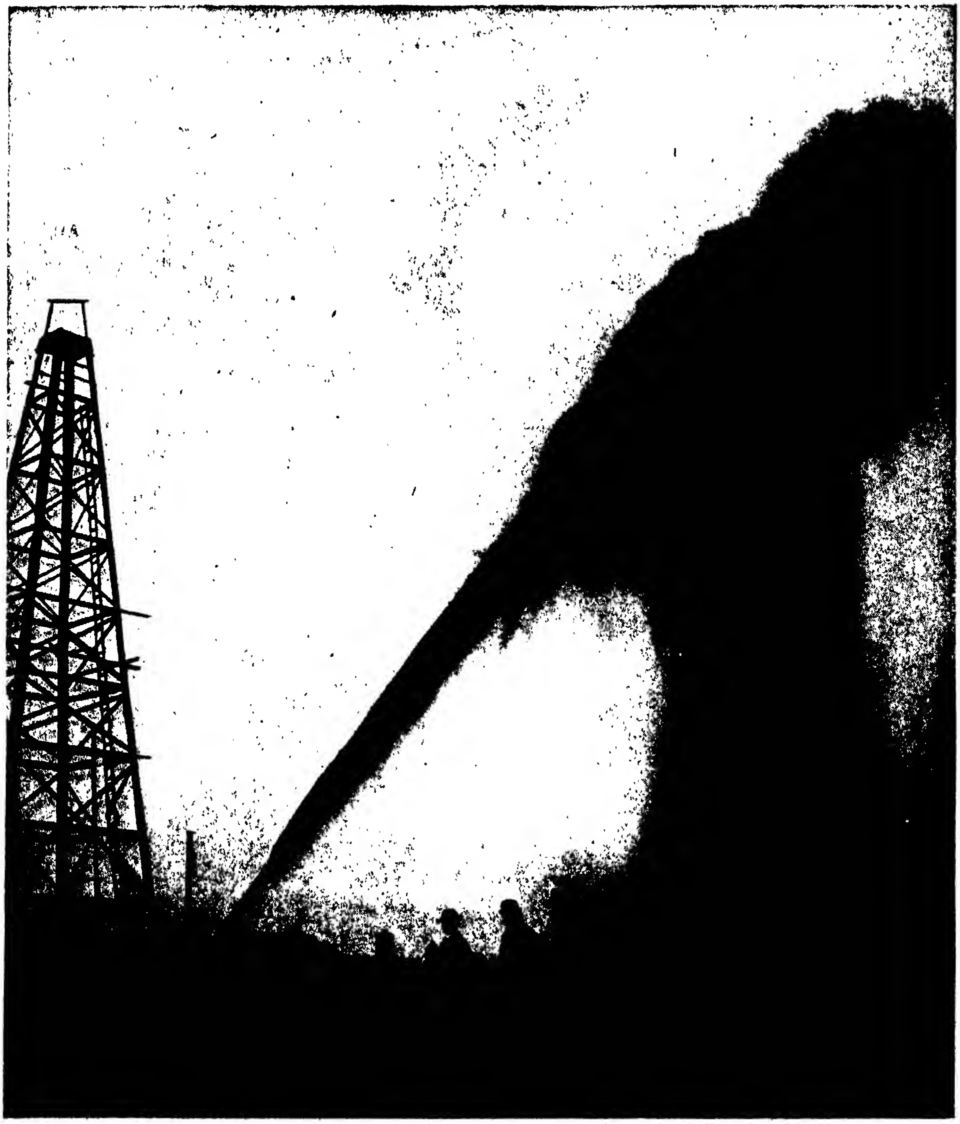
HOW THE OIL IS GOT OUT OF THE EARTH



The oil is got out of the depths of the earth's crust by sinking artesian wells. Sometimes the oil gushes out without any assistance, but more often it is pumped out into tanks as shown in this picture.

A MILLION GALLONS OF OIL THAT RAN AWAY

A GREAT LAKE OF A MILLION GALLONS OF OIL THAT RAN AWAY BEFORE A WELL COULD BE CONTROLLED



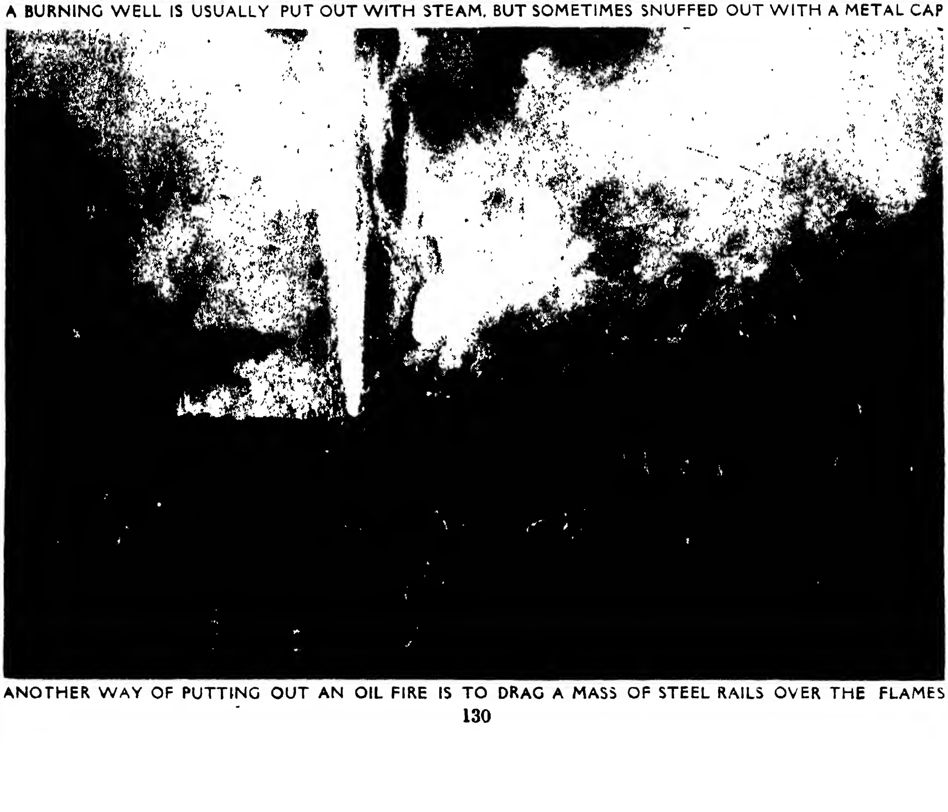
A TYPICAL GUSHER, OR SPOUTING SPRING OF OIL, WHICH YIELDS SOMETHING LIKE 300,000 GALLONS A DAY

THE LOCKED-UP ENERGY OF A MILLION YEARS

As soon as it is tapped, the oil often spouts out with a tremendous force that carries it fifty feet high. Millions of gallons may run to waste in a few hours, and men dressed in leather suits and metal helmets fix steel caps over the gushing well to control the output. The work is very difficult and dangerous.

TWO WAYS OF PUTTING OUT AN OIL FIRE

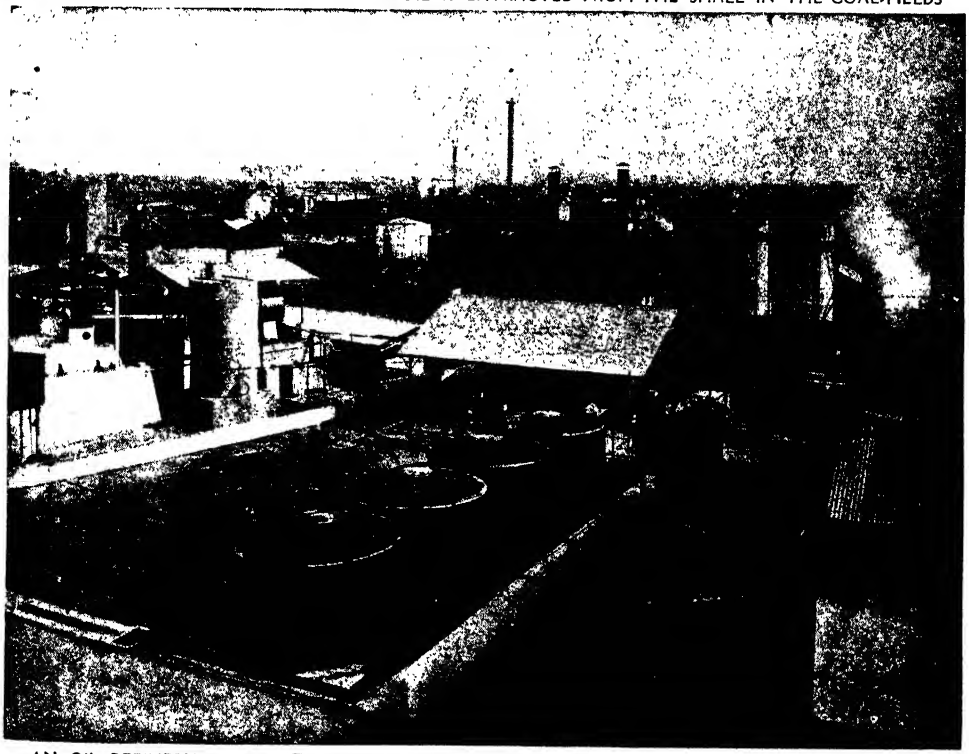
A BURNING WELL IS USUALLY PUT OUT WITH STEAM, BUT SOMETIMES SNUFFED OUT WITH A METAL CAP



ANOTHER WAY OF PUTTING OUT AN OIL FIRE IS TO DRAG A MASS OF STEEL RAILS OVER THE FLAMES

WHERE THE OIL IS PREPARED FOR USE

A GREAT WORKS IN SCOTLAND WHERE OIL IS EXTRACTED FROM THE SHALE IN THE COAL-FIELDS



AN OIL REFINERY WHERE THE PETROLEUM IS PURIFIED AND PARAFFIN IS PREPARED FOR USE

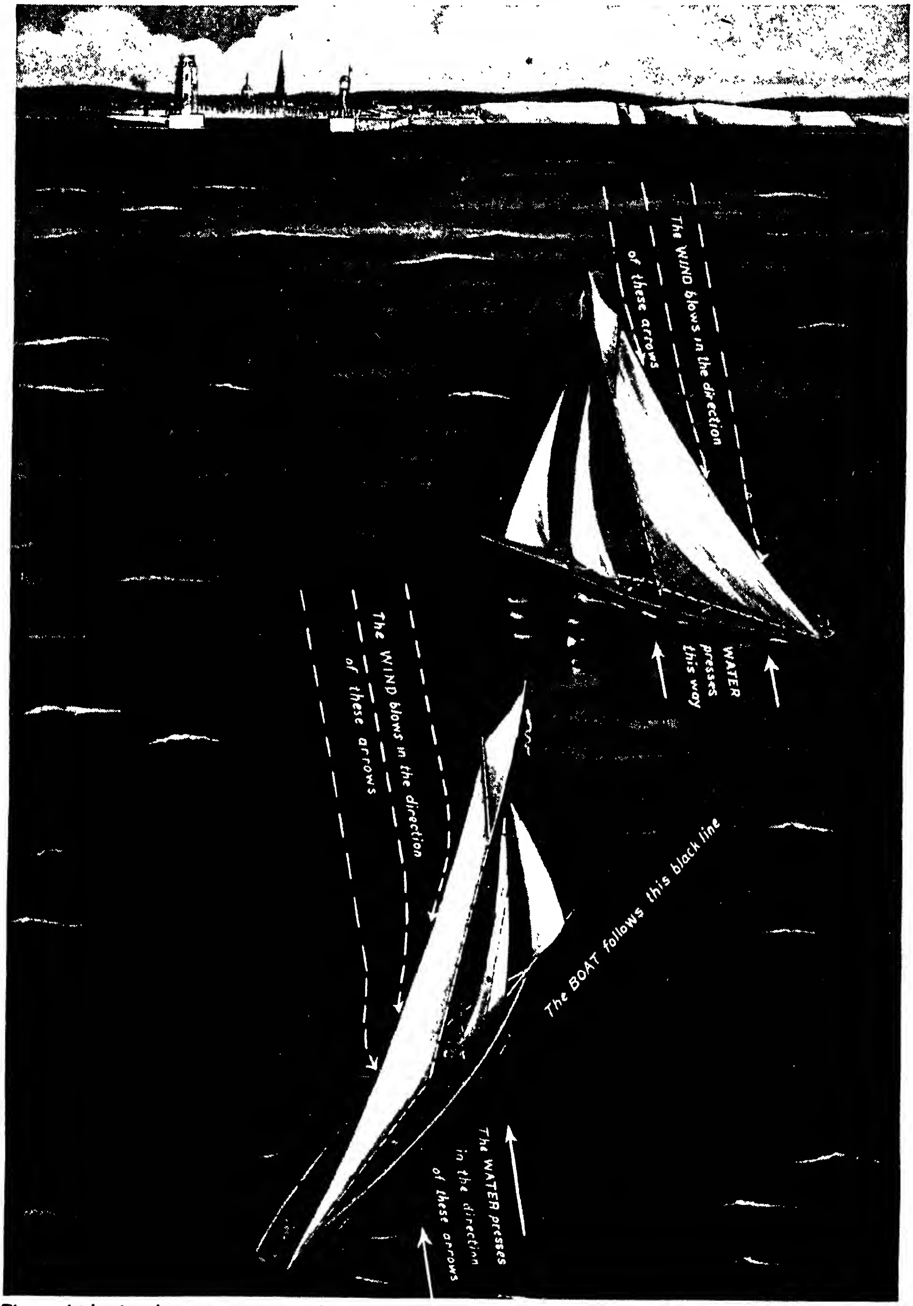
THE TERRIBLE SPECTACLE OF AN OIL-SHIP ON FIRE, WITH ITS MOVING MOUNTAINS OF SMOKE

WHEN AN OIL-SHIP CATCHES FIRE, THE DANGER TO OTHER SHIPPING IS VERY GREAT, FOR THE FLAMING OIL MAY COVER A HARBOUR OR DOCK AND SET A WHOLE FLEET ON FIRE. THE BLACK SMOKE CAN SOMETIMES BE SEEN FORTY MILES AWAY. THE SHIP IN THIS PICTURE WAS REPAIRED AND SENT TO SEA AGAIN

THE UNKNOWN MAN WHO BLESSED THE WORLD

AN IDEAL STATUE OF THE UNKNOWN MAN WHO FIRST BROUGHT OIL OUT OF THE EARTH AND GAVE A NEW BLESSING TO MANKIND

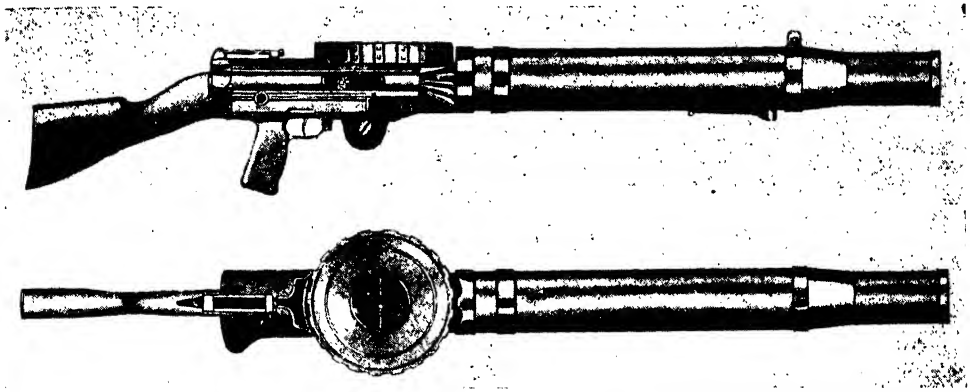
HOW A BOAT SAILS AGAINST THE WIND



The yacht in the picture wants to get into the harbour, but the wind is blowing directly against it. The sails are therefore arranged so that the wind blows upon them at the angle shown. This tends to push the boat sideways, but the water on the opposite side resists. The boat is prevented from going backward by the position of the rudder and by the pressure of the wind at the rear of the mainsail. It therefore moves where there is least resistance, namely, in the direction of the black line. After going for some distance, the position of the rudder is changed. The boat turns, and the sails are arranged on the other side of the boat, which moves forward in the opposite direction. By following a zigzag line, the boat reaches the harbour.

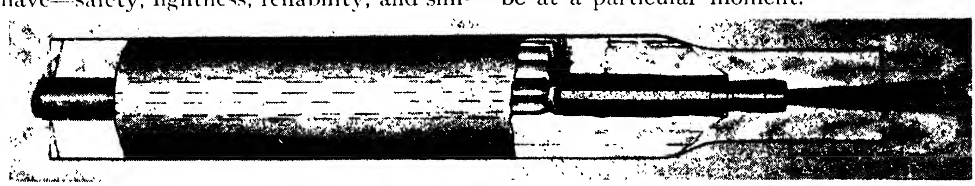
What You Should Know
ABOUT A MACHINE GUN

THE mechanical wonder of the war was the little machine gun. In four years it must have destroyed millions of lives. It will do the work of thirty men. In olden days a man would fire two shots a minute at most with his primitive gun; the machine gun can fire six hundred shots a minute. If we can forget the terrible work it does, this gun must fill our minds with wonder at its cleverness. It works by explosions. It generates a tremendous power, and traps it in the thousandth of a second to work like an engine with the subtlety of a watch.



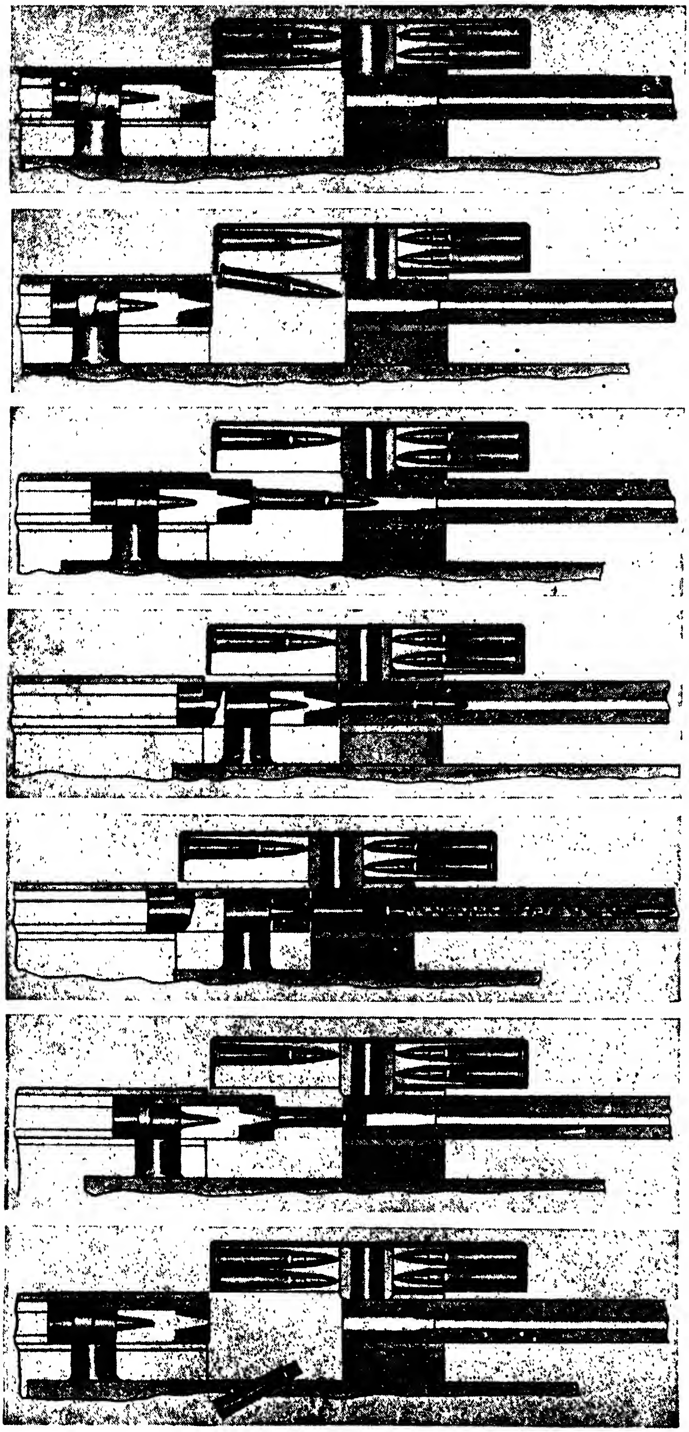
1. THE GUN THAT LOADS AND FIRES ITSELF. TOP AND SIDE VIEWS OF THE LEWIS MACHINE GUN

1. All machine guns have the same essential parts, and these pictures show what they are like. In the Lewis gun the magazine which contains the live cartridges is drum-shaped; in the Maxim it is a belt. In all these pictures we take the gun invented by Colonel Lewis, of the American Army. It has all the qualities a machine gun must have—safety, lightness, reliability, and simplicity. It must be capable of being taken to pieces and put together by unskilled men, and must not be liable to sudden breakdowns. We see from these two pictures something of the strength and compactness of this gun, with its neat circular magazine moving round automatically and delivering the next cartridge exactly where it should be at a particular moment.



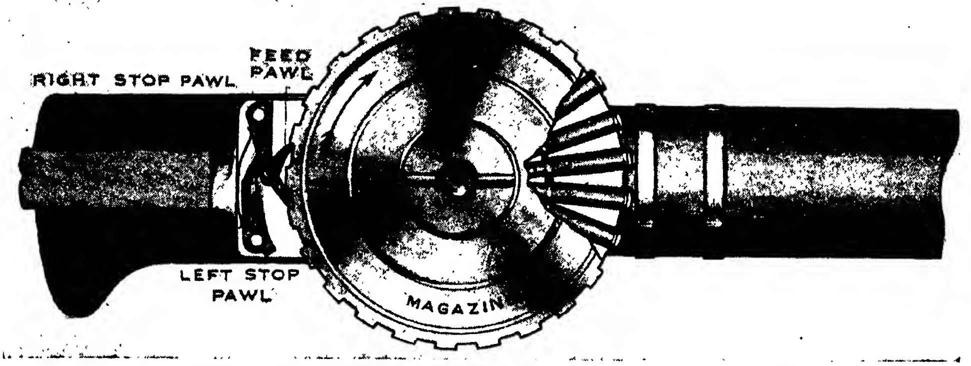
2. THE RUSH OF COLD AIR THAT CARRIES OFF THE HEAT OF THE BARREL

2. The explosion of hundreds of cartridges a minute in the narrow barrel of a machine gun generates terrific heat, and a gun would soon be useless if this heat could not be got rid of. Everybody knows the radiator of a motor-car, through which a stream of air or water runs to keep the engine cool. There is an air-radiator round the barrel of this gun. The barrel itself is the narrow central tube, the outer casing is the radiator-cover. The radiator itself is ribbed, as seen in this section, and, being made of aluminium, is an excellent conductor of heat. It carries the heat away and keeps the gun in working order. So great is the heat generated in the barrel that it would boil a gallon of water in just over a minute. The gun would be dangerous to use if this heat were not controlled. It is one of the clever devices of the Lewis gun that the rush of gas through the barrel after firing causes a sharp draught of cold air to run through the radiator-tube and carry off the heat the radiator-ribs have taken from the barrel.



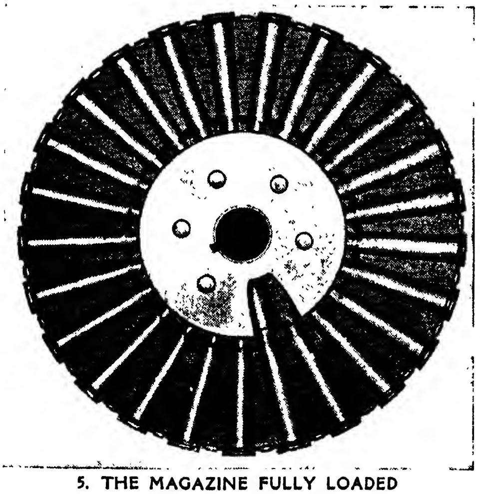
3. WHAT HAPPENS TO THE CARTRIDGE

3. The machine gun fires its cartridges as fast as you could count them. This series of pictures shows the ingenious way in which the cartridge is dealt with. We shall see in a minute how the magazine moves round; in the first of these pictures we see a section through the centre, showing it fully loaded. One of the cartridges is ready to drop, and in the second picture it is seen falling, pushed down by a kind of spring. It reaches a point level with the breech, and now what is called the bolt moves forward and pushes the cartridge into the barrel. The fourth picture shows the bolt close up and the cartridge right home. The bolt is now securely locked so that the explosion cannot move it. The fifth picture shows the striker hitting the back of the cartridge and the bullet speeding on its way through the barrel. We have now finished with the bullet. It will fly through space at half a mile a second. We have still, however, to get rid of the empty case it leaves behind. We see in other pictures how this is done, but here we follow the process briefly to its end. At the front of the bolt are two clips, called extractors, which grip the end of the cartridge-case. The moment after the gun is fired the bolt is unlocked and flies back. As it flies back, what is called an ejector springs into action and knocks the empty cartridge-case out of the grip of the extractors, so that the case falls through an opening on to the ground.



4. THE MAGAZINE THAT FEEDS THE CARTRIDGES INTO THEIR PLACE

4. As one cartridge is fired another must be ready to follow, and they slip into their places, if need be, at the rate of ten a second. This picture shows how it is done. The cartridges lie in a spiral in this round case, the edges of which are toothed, as we see here. When the gun is working, the power of the piston is put behind three little levers, called pawls. There is a feed-pawl, a left stop-pawl, and a right stop-pawl. The business of the feed-pawl is to push the magazine round, so that the next cartridge is ready when the moment comes. The right stop-pawl fixes itself into the teeth of the magazine so as to hold it fast until the time comes for it to move; when that time comes the pawl is pulled back, and the feed-pawl pushes the magazine on. The left stop-pawl fixes itself into the teeth of the magazine so that it shall not slip backwards, but in this picture it is pulled back so as not to hide the feed-pawl, which is underneath. It is the feed-pawl that turns the magazine; the other two fix it tight, so that it cannot move until the actual moment comes.

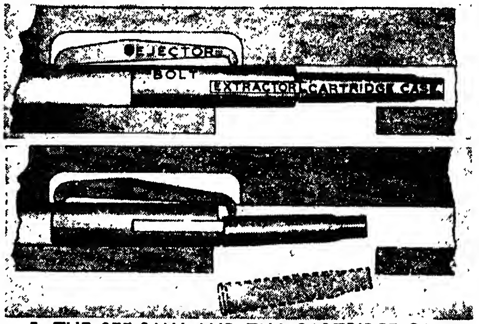


5. THE MAGAZINE FULLY LOADED

5. Lying so still and looking so attractive, like a toy for a boy to play with, the magazine of a machine gun is one of the most terrible things on earth today. Half the terrible work of the war issues from this magazine of death.

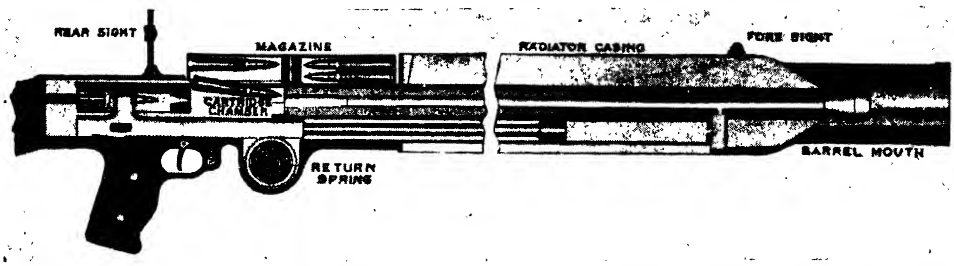
6. THE EXTRACTOR GRIPPING THE CARTRIDGE-CASE

6. Here we see one extractor on the front of the bolt about to grip the case and pull it out after the cartridge has been fired.



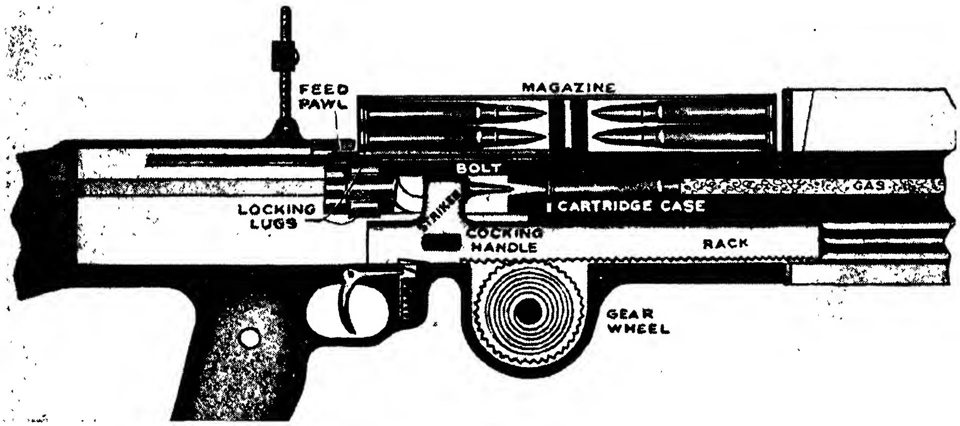
7. THE SEE-SAW AND THE CARTRIDGE-CASE

7. The bolt having started back, dragging the cartridge-case with it, the ejector comes into play. As the bolt moved forward it pushed up the front of the ejector, as seen in the upper picture. As the front rises the back falls like a see-saw. The bolt now flies right back, pushing up the back of the ejector so that the front falls. The front as it comes down sharply taps the back of the cartridge-case, and pushes it out of the extractors so that it falls to the ground.



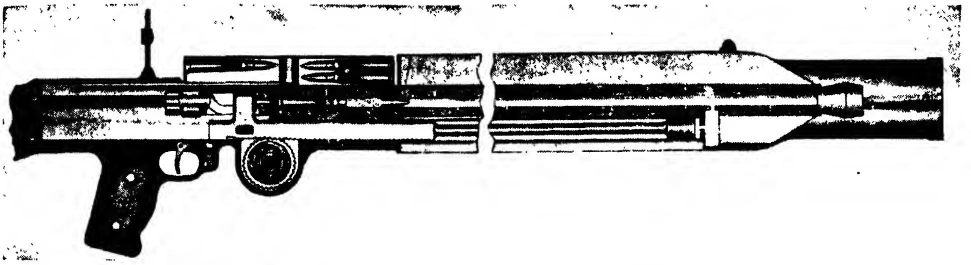
8. INSIDE A MACHINE GUN THE MOMENT BEFORE FIRING (Read across the two pages

8. The pictures on this page show the marvellous way in which the machine gun works itself. The large picture of the working parts should be studied carefully. Picture 8 shows the cartridge falling. If it is the first time of firing, the cocking-handle must be pulled, and then the trigger—a machine gun must always be started with the trigger, but once started it will run itself as long as the trigger is held and as long as it is fed with cartridges. This power of the gun to work itself is one of the mechanical achievements of the age we live in. The inventor of this gun has harnessed the mighty power of an explosion and made it work a marvellous machine, so that another explosion occurs. It is the power of these explosions and nothing else that works this gun, and the pictures on these two pages help us to understand it. Here we see the piston beneath the barrel pushed back as far as it will go. In coming back the piston is made to wind up a spring, and it is the unwinding of this spring that pushes the piston forward again.



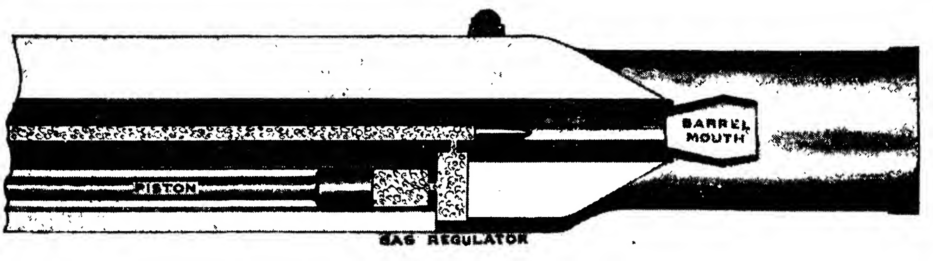
10. INSIDE A MACHINE GUN AFTER THE MOMENT OF FIRING.

10. We have seen these parts one by one. We have seen how the magazine feeds the breech, how the striker hits the cartridge, how the see-saw ejector throws out the empty case; now we see the marvellous way in which the power of an explosion is harnessed to all the subtle movements of this amazing gun. The locking lugs have locked the bolt tight, and everything is held in place so that it can stand the shock of the explosion. The trigger has released the striker, the striker has hit the cartridge and flown back, and the whole of this wonderful mechanism now depends on the thousandth part of a second that it takes the bullet to pass through the barrel. It is only within this twinkling of time that the power of the gas can be trapped; the moment the bullet is out the gas flies after it. And what happens is that the gas imprisoned in the barrel rushes through the hole near the end. Here it finds itself in a little chamber, where it is cleansed from its impurities, and from this chamber the gas rushes through another hole into the piston-cylinder. It comes up against the piston and flings it back, and the whole mysterious process of the working of the gun is now assured. Fixed to the end of the piston is a toothed rack, with its teeth fitting into a gear-wheel, and in the centre of this gear-wheel is fixed the spring



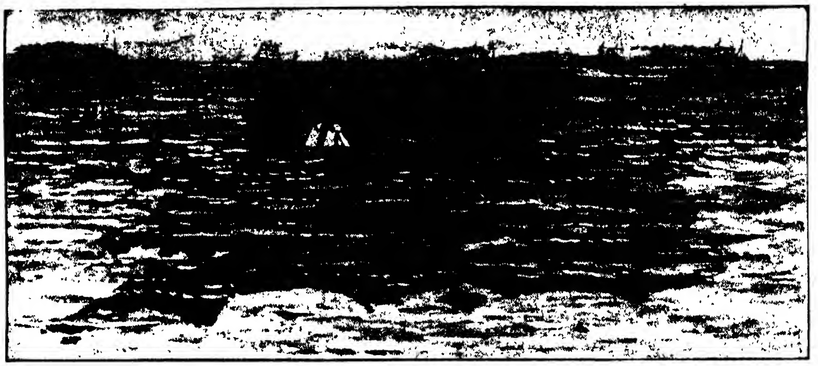
9. INSIDE A MACHINE GUN AT THE ACTUAL MOMENT OF FIRING

9. Here the striker has just hit the cartridge, and the bullet is leaving its case. The explosion has just occurred, and its force is tremendous. The pressure at the moment of explosion is sometimes as much as sixty tons for every square inch, but the sixty tons falls to about six tons by the time the bullet reaches the barrel-mouth. In this picture the piston is as far forward as it can go, and the spring is unwound. What must happen before the gun can fire again is that the piston must fly back and wind up the spring, and this does happen by an arrangement as ingenious as anything that man could devise. The tremendous gas-power generated by the explosion is used, of course, in driving the bullet on its way, and it follows the bullet through the barrel and is lost; but some of it is caught in a trap before the bullet leaves the barrel. It passes through the little passage seen near the end of the barrel in this picture, and it drives the piston and the bolt back and winds up the spring again.



WHILE THE BULLET IS ON ITS WAY THROUGH THE BARREL

we have already seen. As the piston flies back the rack flies back too, and turns the gear-wheel round, so winding up the spring. There are other things the piston does when it flies back—it carries back with it the striker and the bolt, and it enables the feed-pawl to turn round the magazine and bring the next cartridge into its place. All this the piston does before the bullet leaves the gun, and now, with the bullet gone, the power that drove the piston is gone too, for the gases rush out into space. Their energy is spent, but they have done their work, and, most of all, they have wound up the spring. Had the gas remained, pushing the piston back, the spring would remain wound up, but, with the gases spent and nothing to resist it, the spring unwinds like a lightning-flash and drives the piston on. Flying forward, the piston draws the bolt and works all the marvellous mechanism in the gun. The feed-pawl slips into the next tooth of the magazine, the nose of the next bullet is guided downwards, the bolt presses it home in the breech, the locking lugs fix the bolt fast, the striker leaps forward and hits the cap, and there is a new explosion. So the wonderful round goes on, generating power and harnessing it to these levers and wheels and springs, so that they work with the perfection of a watch 600 times a minute.



WILL ENGLAND BE DROWNED?

It is certain that England has been under the sea. The very streets of London stand where the untracked seas of distant ages rolled. It is also certain that England was once part of the continent of Europe—that dry land filled, for instance, what are now the Straits of Dover, and we find remains of the early men alike in England and on the Continent, of which England was then one corner.

The sea and the land in this part of the world have, therefore, altered their level many times, sometimes in one direction and sometimes in another. And if we study the causes of these changes, we learn that they are causes which are still at work. The main distribution of land and water on our planet has been constant for untold ages. If we remember that the depths of the Atlantic and Pacific Oceans are to be measured in miles, we shall understand that they cannot change places with the continents very readily or very quickly. But it seems clear that there are always going on slow up-and-down movements in the earth's crust, which tilt the water sometimes a little in one direction, and sometimes in another, so that low-lying land and shallow sea-bottom change places.

These are only the surface results of deep causes, and the two chief causes are, first, the slow shrinking of the interior of the earth as it cools, leaving the crust to wrinkle and settle down upon it; and the production of heat by radium in the rocks of the earth's crust, causing certain parts of it to expand and rise, so tending to tilt the waters off them.

Compared with these deep causes, there need be little said of the influence of frost and wind, and rain and rivers and waves, and so on, wearing down the land on its surface and at its edges, but these causes, like the others, are always at work.

Thus, it cannot be supposed that England will always be above the sea. Some day she may be even more above the sea than now, and will be part of Europe. And, after that, or before it, or both after and before it, she will doubtless sink beneath the sea, and the waves will roll and fishes swim and boats float over London.

In that day, men will know which lasts longest—matter or mind. Our buildings and our bridges, our streets and our monuments, our railways and our breakwaters—all will be gone. And fools would say that that was the end of England. But wherever men walked the earth, and even in the ships that sailed over the ruins of our cities, Shakespeare would be read, and the English Bible loved, the work of Newton would be honoured, the compass of Kelvin or its successor would guide the sailor, and Lister would protect mothers when babies are born, and save lives everywhere, as he does to-day.

And would that be the end of England? Or is it easier to drown matter than man's unconquerable mind, England's body or England's soul?

No man likes to meet a crocodile like this, but nobody fears to carry him in his pocket like this. The right-hand picture shows the editor's pocket-book, made of crocodile skin.

NOTHING LIKE LEATHER

STORED up in our popular proverbs is a vast amount of truth and sense, based upon the experience of men who have lived in all ages of the world's history.

According to one of these proverbs, "there is nothing like leather," and although we do not know who first made that statement, we do know that it is true, justified by the experience of thousands of years. There *is* nothing like leather, and, notwithstanding that clever men, with all the genius of the inventor and all the skill and knowledge of the scientist to help them, have worked hard to invent a substitute for leather, something that could take its place and do its work in the world, they have all failed. Leather stands alone; it cannot be imitated, although the demand is ever growing and has always exceeded the supply. It comes from the skins of animals, and every bit of leather in the world was once alive.

Leather-dressing was one of the most important trades among the ancient Egyptians, and at Thebes, in the days of Egypt's glory, a special quarter of the city was set apart for the tanners. There they lived and did their work, and so great was the demand for leather that Egypt itself could not provide enough skins. One of the forms of tribute which her kings exacted from conquered nations was a number of skins, to be delivered every year for the making of leather by the skilled Egyptian tanners. In the British Museum we can see to-day splendidly preserved leather straps and belts used for binding round the mummies of men who lived far back in the days of Solomon. The mummies themselves, as they were carried to burial, were often covered with a pall or canopy of soft leather, dyed a delicate blue. The Egyptians used leather for making sandals, braces, belts, bags, shields, harness, sails, cushions, and chair-seats. From them the Israelites learnt the art of tanning, and, although the word leather occurs in the Bible only twice, there are many references to skins, which clearly mean leather.

The Greeks and Romans made leather, and indeed it is difficult to find any nation, ancient or modern, civilised or uncivilised, to whom leather of some kind has not been known. The most extraordinary things have been made of it. The Romans at one time had their coins of leather, and some of the early cannon were made of leather, for we read of a leather cannon, made at Edinburgh in 1778, being fired three times with great success.

In the making of leather from the rough skins of animals different processes are used, according to the kind of leather wanted, but they are all based upon the same principle, and are very similar. It is curious to know that the methods used by the Egyptians three thousand years ago are very much like

the methods used in London to-day. Whereas in most other industries modern science and invention have completely transformed the processes of manufacture, and made it possible to do in a tenth of the time, and with a better result, work that was formerly done by hand, in the tanning of hides and skins it has been impossible to hasten and improve the process to any very large extent.

AN OLD MYSTERY EXPLAINED

The animals whose skins make the best leather are those living in hilly and mountainous countries, where they are exposed to great changes in temperature. They become hardy, and their skins are very tough. The skins of the big, fat cattle that we see in shows at Christmas-time are of very little use for leather, having become too much stretched and too greasy. Young animals provide better leather than old ones.

Before they can be made into leather the skins must be treated with lime, and a curious fact is that the lime used must have been used before for other skins. It was once thought that the lime itself, by some chemical action, loosened the hair, but this has been proved not to be so. As a matter of fact, fresh lime tightens the hair in the skin. The old lime, owing to its contact with former skins, is full of bacteria, the tiny creatures that we can see only through a very powerful microscope, and these bacteria make their way down into the epidermis, destroying the roots of the hairs so that they come away easily. This fact is one of the interesting discoveries of modern science, and it explains for the first time the why and wherefore of a process that has been known and used for thousands of years.

THE ANIMALS THAT GIVE US LEATHER

The skin of any animal can be tanned, but the main sources of our leather supply are the oxen, sheep, goats, and pigs that are killed for food. A good deal of leather is now made from the skins of seals—not the fur seals, but the yellow-hair seals caught off Greenland and Norway and Sweden by whaling vessels.

The skins of crocodiles, lizards, snakes, and frogs are tanned for making small bags, pocket-book covers, and letter-cases. They are too horny for other purposes.

Horse-skin provides an excellent leather, much used for the boots of sailors and fishermen, because it is exceptionally waterproof. Porpoise leather is really made from the white whale, and is very strong. Elephant, rhinoceros, and hippopotamus hides make a very heavy and thick leather. The skins of sharks, buffaloes, antelopes, deer, kangaroos, wallabies, donkeys, and chamois are all tanned, but the supply is too small to make these animals of much commercial importance.

And this reminds us that the world is less and less able to get enough leather for its needs. One of the great problems for boys and girls now growing up will be the leather problem. Where is the world to get its leather from in the days to come? Leather is what is known as a by-product—that is to say, the animals are reared and killed, not for their skins, but for their flesh; and as the skins happen to be there, they are used for making leather. But it would never pay to rear animals simply for their skins.

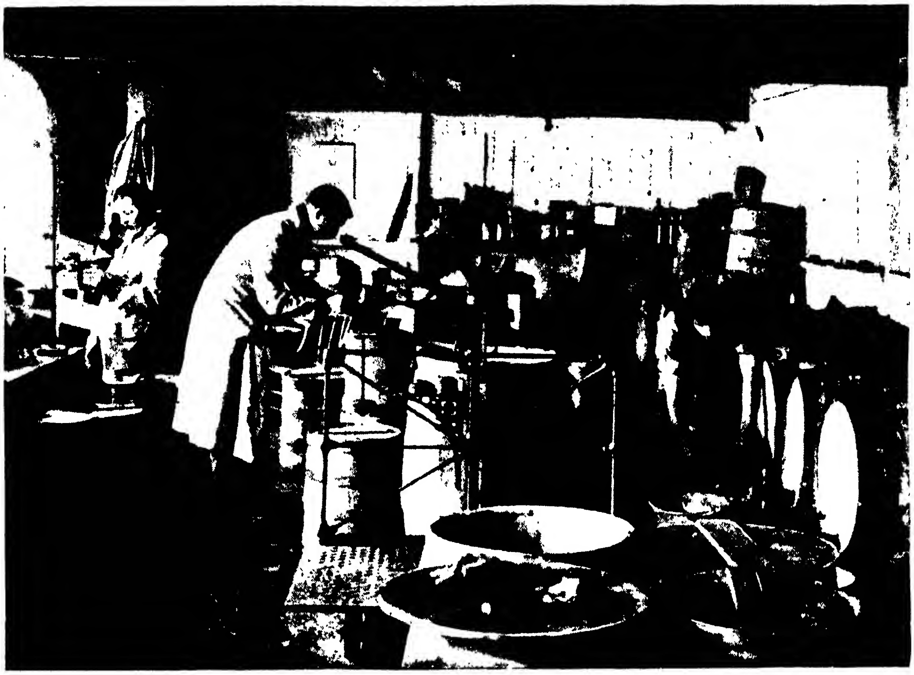
WHAT WILL THE WORLD DO FOR LEATHER?

The demand for leather is increasing every day, but the supply does not increase at anything like the same rate.

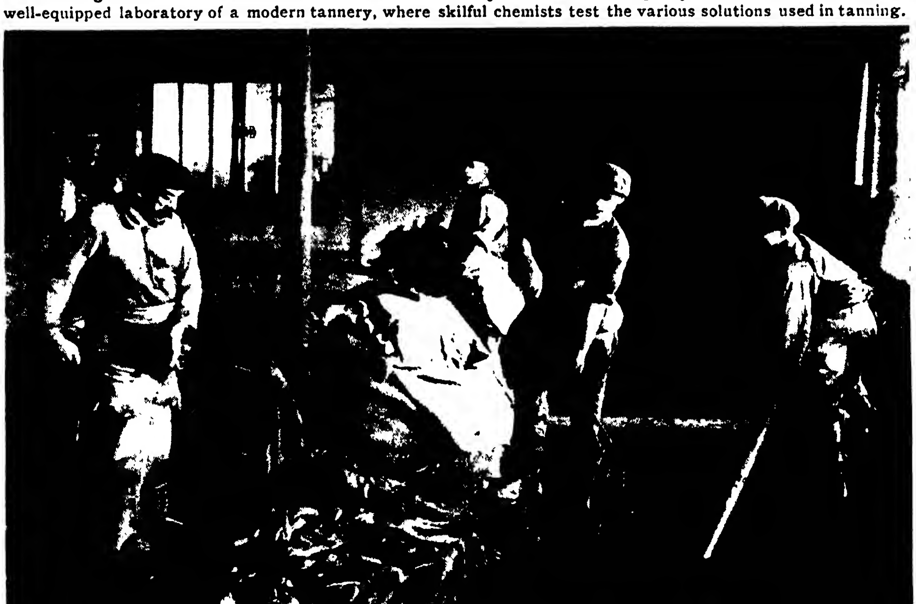
During the last twelve years the price of some leathers has doubled, owing to the great demand, and other kinds cost half as much again as a dozen years ago. The uses of leather have increased also until we count them in hundreds. Leather is used for the great belts that drive our big machinery, and for the small buttons on a boy's coat; it is used for upholstering a motor-car or a railway carriage, and for making a purse or a watch-guard. The coming of motor-cars has greatly increased the demand, and many people of other lands who used to wear wicker sandals or wooden sabots now wear leather boots and shoes. So that far more leather is being asked for than can ever be produced.

The leather comes from animals that are killed for food; but people are now eating less meat than they used to eat, and the increase of vegetarianism and fruit diets is still further limiting the supply of leather. What is the world going to do for its leather in future? No one can say, but we know that as the demand increases, boots and shoes, cricket balls and footballs, bags, book-bindings, motor-cars, belts, harness and saddles, purses, perambulator shades, and a hundred other things made of leather, will become dearer and dearer.

THE VERY BEGINNING OF BOOTS & SHOES

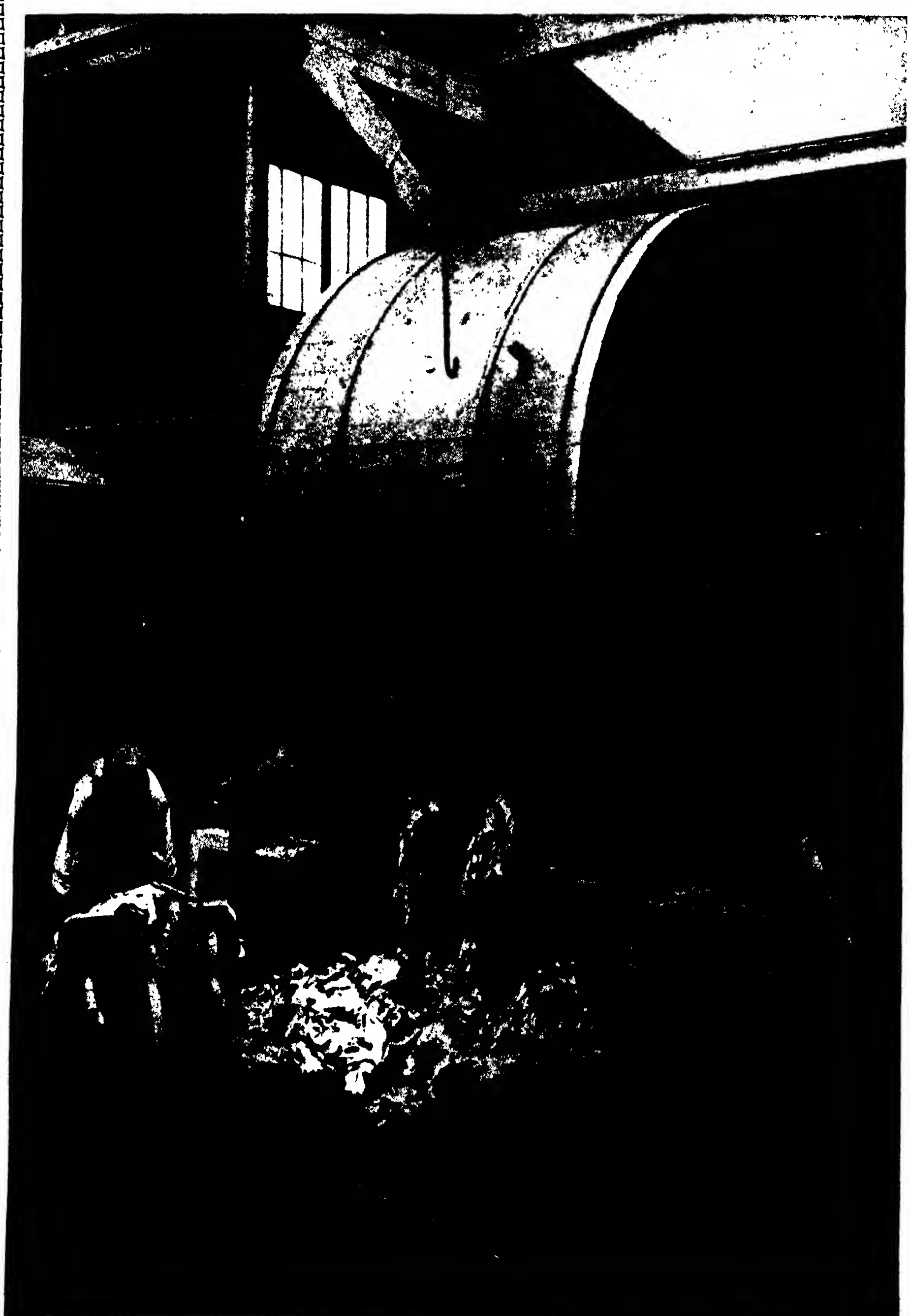


The making of leather from skins of animals is an industry of ever-increasing importance. Here we see the well-equipped laboratory of a modern tannery, where skilful chemists test the various solutions used in tanning.



In addition to the skins of animals killed for food in England, large quantities of dried and salted skins come from abroad. They are first of all, as shown here, put into pits of water containing chemicals to make them soft.

THE BIG DRUM AT THE LEATHER WORKS



After coming from the water-pits where they have been soaked, sometimes for days, the skins are put into a great revolving drum, like that seen in the picture, which contains chemicals, and here they are still further softened.

PREPARING THE SURFACE OF THE SKINS

It is necessary to remove the hair from the skins before they can be tanned, and to do this they are laid out on the ground, as shown in this picture, and covered with a mixture of lime, and then folded up and placed in pits for a time.

After the hair has been loosened by immersion in lime-pits, the skins are laid on boards, and the hairs and outer skin are scraped off with knives. This work needs great skill. Each man can unhair about 250 skins a day.

THE HAIR OF WHICH CLOTHES ARE MADE

The hair that is scraped off goat-skins is collected and passed through this machine, which dries it. It is then sent to the North of England to be made into cloth for cheap clothes. Good goat-hair realises as much as £40 a ton.

The skins now pass through several processes of cleaning before being tanned. The machine in this picture takes all the dirt out of the skin, and removes any short hairs that remain. It will clean about 3,600 skins a day.

HOW THE SKINS ARE TANNED INTO LEATHER

After cleansing, the skins are ready for tanning, in which processes vary greatly. The pictures on this page show what is known as chrome tanning. It produces the strongest leathers. Here skins are being taken out of a drum of acid.

These men are putting the skins that came out of the drum in the top picture into a second tanning bath. It will be seen that in both pictures most of the men wear gloves. This is for protection, as the acid causes serious wounds.

SHAVING THE SKINS TO ONE THICKNESS

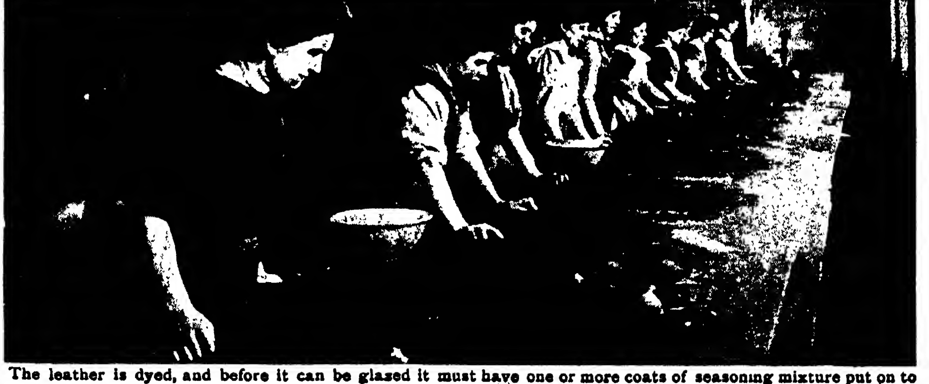
After being tanned, each skin is made of the same thickness throughout, and this machine shaves off all inequalities. It has to be worked carefully or the skins would be damaged. The machine shaves nearly 1,000 skins a day.

Other processes follow, and the skins are then oiled. This helps to make them waterproof. They are next placed in ovens to be dried. In many of the processes of leather-making no satisfactory machinery has yet been invented.

PREPARING TO GLAZE THE LEATHER

The skins, having been dried, are now damped again by being packed in wet sawdust. These youths are very quick at the work, and can pack away as many as several thousand skins a day in the sawdust baths, or pits.

The next process is to pass the skins through a staking machine like those shown in this picture. The skins go through the machine twice, and, as a result, are rendered soft and pliable, and have the stretch taken out of them.



The leather is dyed, and before it can be glazed it must have one or more coats of seasoning mixture put on to make it take the glaze, and that is what these girls are doing. Women are able to do this much better than men.

"THE FIRST SHINE ON A PAIR OF BOOTS"

In the left-hand picture a skin of leather is being glazed by a machine which rolls a glass cylinder over it very rapidly, giving what may be called "the first shine on a pair of boots." On the right the skin is being trimmed.

Here the finished skins are shown being sorted according to their substance or weight. This is work that demands very great skill and knowledge of leather, and every man who attempts it must be a thorough expert at his trade.

THE MACHINE THAT MEASURES THE SKINS

The skins are sorted up according to colour, and as the shades vary very much the work of sorting is one that needs a skilled eye, and it has to be done by the aid of a north light—that is, before a window that faces the north.

Before being passed to the warehouse for sale, the skins must be carefully measured, as they are sold at so much per foot. This measuring is done by the machine shown here, which measures more than two thousand skins a day.

THE FRIEND WHO PLUCKS THE LEAF FOR YOU

The picking of the leaf is now practically the only part of the manufacture in which the tea is touched by hand. This woman, as she plucks the young leaf-shoots, puts them into the basket supported on her back by a band round her head.

The photographs on these pages are taken by the India Tea Association, Davidson & Co., Marshall & Co., Underwood & Underwood, and others.

Tea-pickers at play after a day in the tea gardens in India

THE STORY IN A TEACUP

We think little enough of the tiny leaf which floats in our cup of tea, yet the little leaf has had a world of adventure. It may have grown in China, or more likely in India or Ceylon. It has sprung up on land rich with the leaves and fibres of a dead forest; it has borne the intense heat of the burning sun, and flourished through the heaviest rains.

It may have reached its prime on a sheltered plain, or attained perfection on a loam-strewn mountain-side, at a height greater than any in Great Britain. And when the life of the leaf upon the plant is ended by the picker, complicated machinery takes it and bakes it and ferments it and sorts it and packs it, and sends it forth, the precious gift of the East to the West.

Nobody can say for certain where the first of these plants grew, but we know that for about two centuries all the tea brought to England came from China. It first made its appearance here early in the seventeenth century, and so great a novelty was it that people paid from five to ten sovereigns a pound for it

At such a price it could never have become popular, but fully a hundred years later it still realised from twenty to thirty shillings a pound in London, and the principal shop at which it was sold combined the business of tea-dealing and banking. As more and more tea came into the country, prices became lower, and so great was the demand that the fastest ships in our merchant service were devoted to the tea trade. As soon as they got their cargo of the leaf they had to race home, and the ship which arrived first got the best price for the new season's crop.

If drunk in large quantities, or when it is too strong, tea is injurious; but rightly made, and drunk in moderation, it is one of the most delightful of beverages, and has done splendid work in Great Britain in helping to banish alcohol from the table. But when it first came into general use many mistakes were made in brewing the tea. Robert Southey, the poet, has told us how friends of his, on getting their first supply, carefully made their brew in the kettle, threw away the liquid, and then solemnly sat down to eat the leaves with butter and salt!

With the growing demand for tea from China, the East India Company wisely thought that they might introduce the growth into India, so they sent to China for seeds. But while the messengers were yet on their way tea was discovered growing wild in Assam. There, in the favoured home of the tiger, rhinoceros, leopard, elephant, buffalo, and bear, grew the friendly plant which all desired. Planters lost no time in cultivating it, and in 1843 the first cargo of Indian tea was placed on the London market.

Immense numbers of men and women and children are engaged in the cultivation of the tea plant. Happily,

their labour is not very hard. Their pay amounts to only a few pence per day, but their requirements are more easily met than are those of people in western lands, where the cost of living is higher and the manner of life different.

A tea plant is ready for the picker when it is about five years old. The pickers, carrying a basket slung upon their shoulders, and supported by a band passed round the forehead, enter the plantation, and go from tree to tree. They take only a few buds and young tender leaves from each, then pass on to the next. As they pick the leaves and buds they toss them into their baskets, and these, when filled, are carried to the factory, and their contents weighed. The plant continues to grow all through the warm, rainy season, and the picking goes on from day to day as the new leaves and buds come out.

THE TEA GOES ON ITS WAY TO THE SHIP

It is at the factory that the process of preparing tea is carried out. The tea is first emptied out on to shallow trays, and a pound of tea covers an area a yard square. The trays bearing the tea are carried to a heated room, through which a strong current of air is forced. This is to soften and wither the tough leaf. Next the leaves are passed through a machine which curls them. Following this the tea is spread out or placed in drawers, and covered with damp curtains. The heat and moisture cause the tea to ferment, after which it goes through a sort of baking process for a few minutes to dry out the moisture caused by fermentation.

The leaves have now to be sorted into sizes and qualities, sieves of various meshes being employed for the purpose. Then, after a second drying, the tea is ready for market. It is packed by machinery into chests lined with lead, and away it goes to the ship. The process, of course, varies in different districts.

WHEN THE TEA SHIP ARRIVES

So far we have been thinking of the Indian method of treatment, in which, from the time that it is picked, the tea is not handled at all. In China the process is different. There the tea is rolled by hand and trodden by foot—a nasty method. Even there, however, the voice of public opinion is being heard, and machinery is being introduced.

When the tea reaches Great Britain its adventures are not nearly ended. It cannot pass straight on to the counter of the shopman. It is one of the articles upon which a tax has to be paid in Free Trade England. Until that tax has been paid the tea cannot enter the country. The merchants who are sending it over pass it into bond—warehouses controlled by Excise officers. But tea-merchants will not buy tea without knowing its quality and flavour, so samples have to be brought out of bond, a quantity of tea equal to that withdrawn being taken in at the same time so that the Customs may not suffer.

These samples are split up into small quantities, and sent to the various merchants, having been first named and numbered so that the stocks from which they have come can be identified. It is now the duty of the tea-taster to test the samples. He has a tiny pot of tea made from each, and he moistens his mouth with a sip from each brew. Those that he likes, and knows to be of the character required, he commends, and the merchant buys them at the sale.

THE DIFFERENCE THAT THE HOME OF A TEACUP MAKES TO THE TEA

When the tea reaches the merchant's warehouse a new experience awaits it—it has to be blended. The merchant has a book in which are recorded all the different qualities and peculiarities of the water supplied to the districts of the United Kingdom. For each district there is a special blend. A tea which would be satisfactory if brewed in one part of the country would be quite unsuitable to the water of another part, and the blending is therefore one of the most important features of the tea industry. How difficult this blending is may be imagined from what happens on the railways. The main lines run over great reaches of country, tapping a variety of water-supplies. The result is that tea of four or five different blends has to be supplied for the refreshment-rooms on the railways.

The industry which has grown up around the tea plant is a vast and important one. The British people are among the biggest tea-drinkers in the world. Every year we receive nearly three hundred million pounds' weight of tea, which means a consumption in the country equal to about six pounds a year for every man, woman, and child.

THE LEAF THAT REFRESHES MILLIONS

Although tea was introduced into England only about 250 years ago, no less than 270,000,000 pounds is now used in the United Kingdom in a single year. This picture shows how the tea shrubs are cultivated in rows in large plantations.

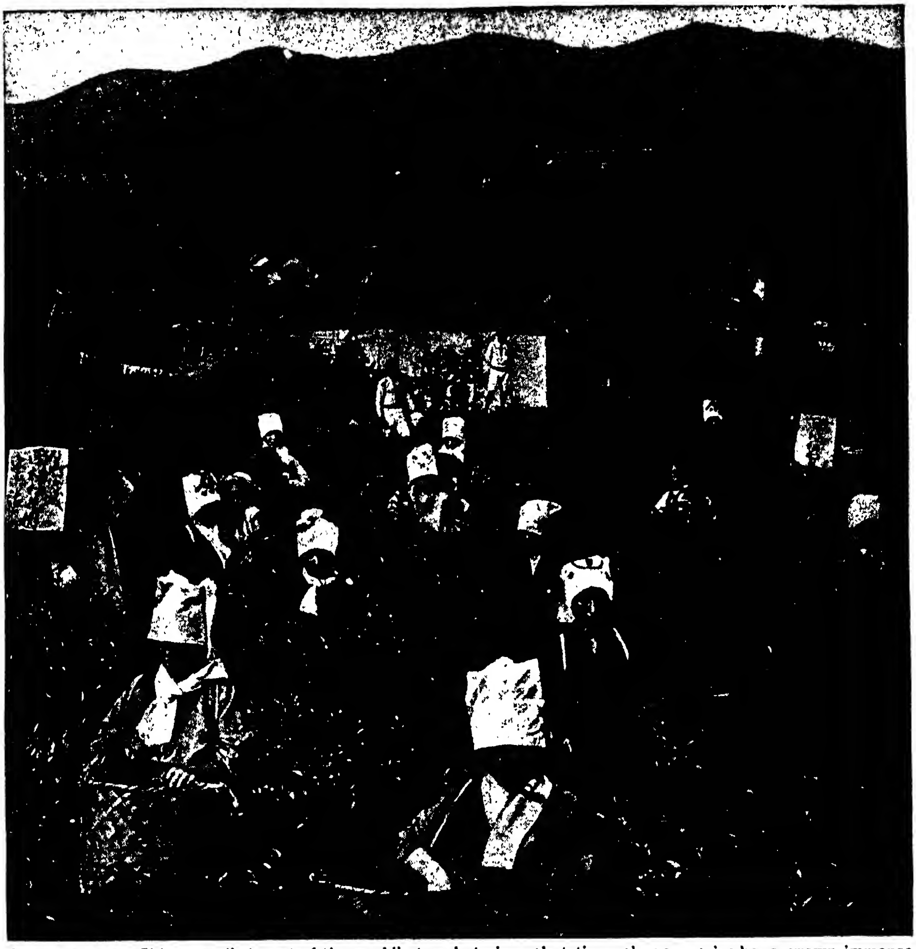
The tea plant is an evergreen shrub with leathery leaves, and white flowers which change into woody seed-vessels. Our domestic teas generally consist of the dried leaves of several varieties of tea plant blended together.

WHAT A TEA GARDEN IS LIKE IN INDIA

Originally nearly all our tea came from China, but in 1836 one pound of tea came to London from Assam, and this was the beginning of the present huge tea trade of India, where half a million people are now employed gathering the leaves.

Many of the tea-pickers are boys and girls, like these little Cingalese, and they are quite as quick and skilful at their work as the grown-ups, shown in the upper picture. India and Ceylon now produce 411 million pounds of tea a year.

A HAPPY TEA PARTY IN A JAPANESE GARDEN



Forty years ago China supplied most of the world's tea, but since that time other countries have grown immense quantities of tea, and Japan now produces more than 40 million pounds a year. Here we see Japanese pickers at work.

The Japanese women in the tea plantations frequently carry their babies tied to their backs, as one mother has hers in this picture. Japan exports much green tea, which is from the same plant as black tea, but is dried differently.

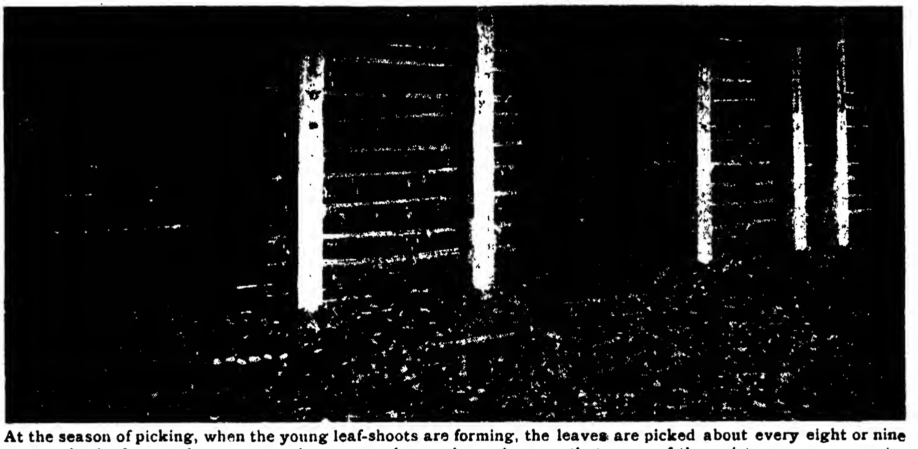
WEIGHING THE TEA AND PAYING THE PICKERS

Twice a day the coolies bring their baskets of leaves to the factory, in order that the stock which they have picked may be weighed, and it is a very picturesque sight when the pickers are gathered together, as shown here.

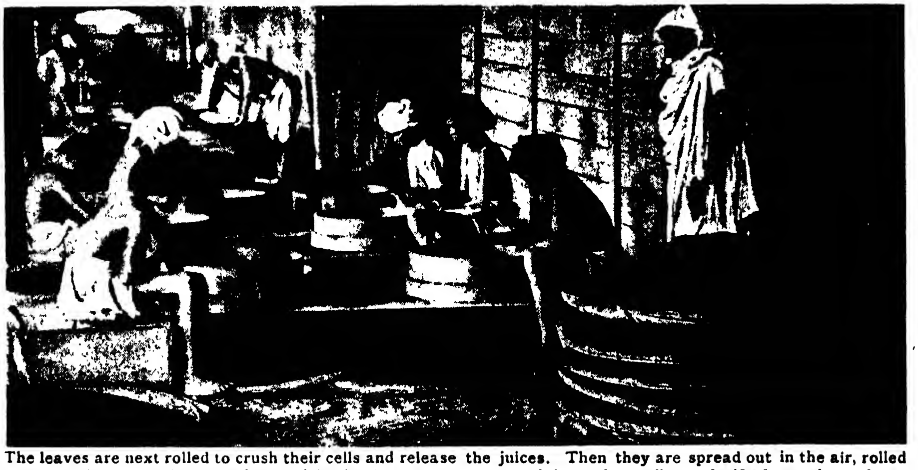
The pickers are paid according to the weight of leaves brought in, and there is much excitement as the baskets are placed on the scale to be weighed. Of course, the quantity picked varies according to the skill of the pickers.

Even more exciting than the weighing is the paying of the wages. The pickers line up and approach the paying-out clerk in procession, each checking his or her money before passing to make room for the next worker

THE TEA LEAVES ARE SIFTED AND DRIED



At the season of picking, when the young leaf-shoots are forming, the leaves are picked about every eight or nine days. At the factory they are spread out on racks, as shown here, so that some of the moisture may evaporate.

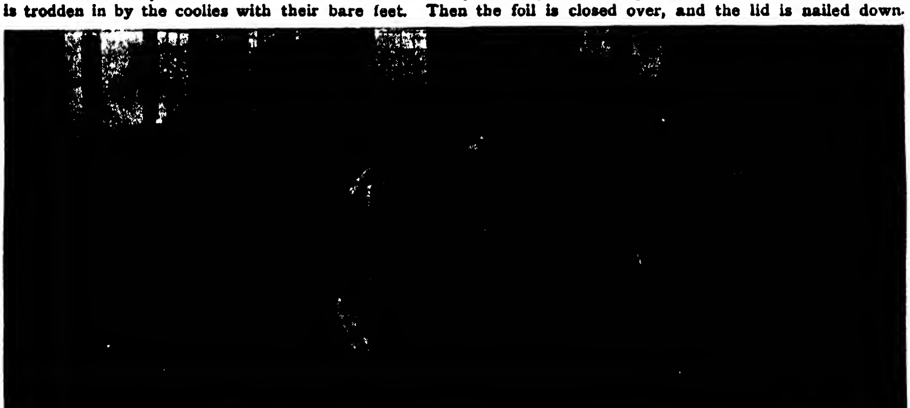


The leaves are next rolled to crush their cells and release the juices. Then they are spread out in the air, rolled again, and fired or baked, after which the leaves are separated from the stalks and sifted, as shown here.

The tea is now fired once again, being placed on trays in what is called a drier, while currents of hot air are passed gradually over it until the leaves become firm and crisp as they are when we buy them. It is then ready for packing.

PACKING THE TEA FOR ITS LONG JOURNEY

The Chinese still pack their tea in the old-fashioned way. It is put into large cases lined with lead foil, and is trodden in by the coolies with their bare feet. Then the foil is closed over, and the lid is nailed down.



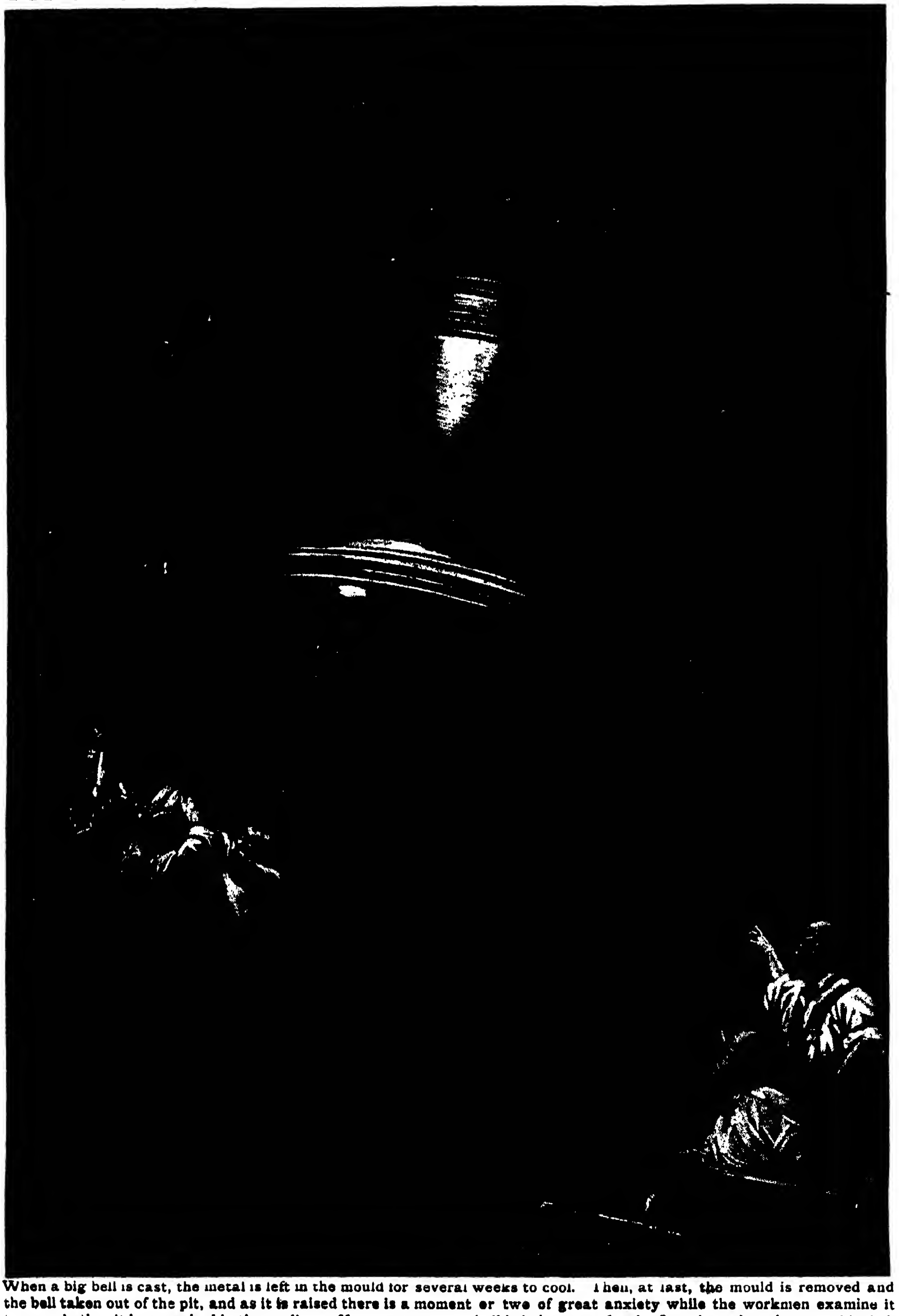
Modern methods prevail in India and Ceylon, from which countries our English tea comes. There, much of the tea is packed ready for the shops in small packets, the metal foil covering being soldered down to keep the tea air-tight.

SENDING THE TEA OUT TO THE SHOPS

The tea that comes over in large cases is bulked and blended in the London warehouses. This means that cases of various kinds of tea are emptied out in one great heap on the floor, and mixed up by men, as shown in this picture.

Then it is packed back into the large cases, pressed down tightly, and sealed up ready for the shops, where we buy it. Australians and New Zealanders are the biggest tea-drinkers in the world, and the English come next.

THE FIRST RINGING OF A GIANT BELL



When a big bell is cast, the metal is left in the mould for several weeks to cool. Then, at last, the mould is removed and the bell taken out of the pit, and as it is raised there is a moment or two of great anxiety while the workmen examine it to see whether it has cracked in the cooling. Here an enormous bell is being rung for the first time, though a very big bell is not usually swung, but is struck on the outside. The great bell of Moscow was left in the earth over a hundred years.

The bell that rings in good news on the Mount of Olives—taking the bell up the Mount

THE SWINGING, RINGING BELLS

THE GLAD NEWS & SAD NEWS THEIR MELODY FORETELLS

IT has been said that a city without bells is like a country without singing birds, and certainly it is as difficult to imagine the one as the other. That must indeed be a sad land in which there live no birds to herald the coming day and to make the sunny hours glad with the music of heaven; and a city with no bells to chime the hours, to call to prayer, and to sound out joy and gladness, must be like a city of the dead.

All the great and solemn occasions of life, all the grand events of national history, all the seasons of joy and sorrow, have for ages been marked by the merry ringing or the solemn tolling of the bells, and it is doubtful if any other form of music has so moved the hearts of men.

Over and over again the poets have been stirred to song by the music of the bells; and as Tennyson tells us of the ringing in of a new year, we can almost hear the voice of the bells speaking to us with their "iron tongues and brazen mouths." Edgar Allan Poe, too, in his famous poem, leads us from the happy tinkle, tinkle of the sledge-bells and "the world of merriment their melody foretells" to the loud alarum-bells, brazen bells. "How they clang and clash and roar," as we read the verses, and at the end it seems as if the din of the bells were still in our ears. Bells, in the sense of the large melodious instruments that hang in our church steeples, are practically a Christian institution, for in Europe, before the birth of Jesus, there were no such bells; and, although in the East large bells probably existed thousands of years ago, their sound was harsh rather than melodious, for instead of being cast in one piece they were built up of metal plates riveted together.

It is in the last thousand years that the making, and tuning, and ringing of bells has been brought to perfection; and during that time the bells may be said to have influenced the lives and histories of the nations. Something of our architecture we owe to the bells, for it was in order to provide a worthy home for them that the beautiful towers and steeples of our Gothic churches and cathedrals were designed and built in days gone by. And even now, although we may not regard the bells with the superstition and reverence of long ago, we still build handsome towers in which to hang our chimes.

It was the bells that summoned the citizens to arms in times of danger, and it was the bells that rang out the triumphant song when victory attended the arms of the people. All the bells of the city would rin out together on a great occa ion, and Victor Hugo gives us a vivid picture of the pealing of the bells of old

Paris, which he calls the singing of the city.

"Lend your ear to this opera of steeples. Diffuse over the whole the buzzing of half a million of human beings, the eternal murmur of the river, the infinite piping of the wind, the grave and distant quartette of the four forests, placed like immense organs on the four hills of the horizon. Soften down, as with a demi-tint, all that is too shrill and too harsh in the central mass of sound, and say if you know anything in the world more rich, more gladdening, more dazzling than that tumult of bells—than that furnace of music, than those ten thousand brazen tones, breathed all at once from flutes of stone three hundred feet high."

And what dark tragedies the bells have heralded! It was at the ringing of the vesper bell on Easter Monday, 1282, that the massacre of Frenchmen in the island of Sicily began, which did not cease until every Frenchman in the island had been put to death, and the tragedy has ever since been known in history as the Sicilian Vespers.

WHEN THE BELLS TOLD THE PEOPLE THE TIME OF DAY IN MERRY ENGLAND

On the morning of St. Bartholomew's Day, August 24, 1572, the ringing of the bells, which had for centuries called men to prayer, was the signal for the terrible massacre of Huguenots that robbed France of her best blood, and made the name of St. Bartholomew a byword among the nations.

There have always been those who could hear the bells speaking to them, and not merely ringing; and we know from our nursery stories how Dick Whittington, the poor starving boy who had run away from the house where he was ill-treated, sat on a milestone by the roadside and heard the bells of Bow Church, in Cheapside, sing out the message: "Turn again, Whittington; thrice Lord Mayor of London."

At one time town and village bells were an absolute necessity. Before clocks and watches became familiar objects of every-day life as they are now, the bells told the people the time of day. They rang early in the morning to call men to work, they rang at midday for dinner, and they rang in the evening to say that work was now to end. The bells were rung as a signal for buying and selling to begin in the market, and we all know how the curfew told the people to put out their fires and lights and to go to bed.

Bells are made of a mixture of metals, consisting of four parts of copper to one of tin. It was at one time thought that a proportion of silver added to the sweetness of the tone, and the old monks used to invite the wealthy to give silver for the making of the church bells. Many old bells, supposed to contain considerable quantities of silver, have been recast in modern times, and their metal analysed, but very little silver has been found. It is thought that while encouraging their supporters to bring silver for the making of bells, and encouraging the belief that this improved the tone, the monks secretly used the silver for other purposes and substituted tin.

THE GREAT BELL OF MOSCOW WHICH HAS NEVER BEEN RUNG

Some bells are of enormous size and weight, but these are not swung in ringing; the hammer is moved, and strikes the bell, either inside or out. The great bell of Moscow, cast in 1733, was left in the earth where it was moulded for 103 years before being raised. It has never been hung, having been cracked in casting, and it now stands on a platform in an open square of the city, and is fitted up inside as a church. It weighs nearly 200 tons, and the piece that was broken out weighs eleven tons.

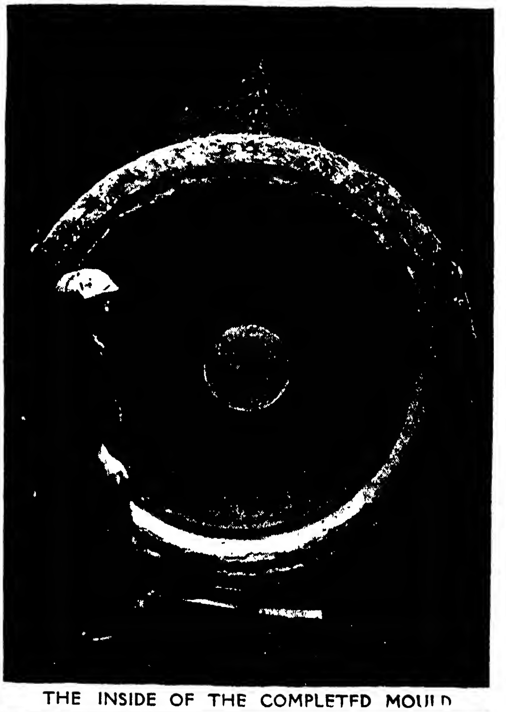
Another great bell at Moscow, which weighs 128 tons, is the largest bell in actual use in the world. The biggest bell in England is Great Paul, in St. Paul's Cathedral, London, which was cast in 1881 at a cost of £3000, and weighs seventeen tons. The largest English bell to be swung is the tenor bell at Exeter Cathedral, which weighs just over three and a half tons. Of course, the swinging of a massive bell causes great vibration in a tower, and from time to time serious accidents have happened. In 1810 the spire of a church at Liverpool fell while the bells were being rung for morning service, and twenty-three people were killed.

ALL HISTORY IS TOO SHORT TO RING ALL THE CHANGES IN ONE BELL-TOWER

Change-ringing—that is, the ringing of a number of bells in varying orders—is a distinctively English institution, and is practised all over the country. The variations in ringing a number of bells is enormous. Twelve bells can be rung in 479,001,600 different orders, and to ring them all at the rate of two strokes a second would take ninety-one years; while to ring all the possible changes upon twenty-four bells would occupy, at the same rate, more than 117 billions of years. That is to say, there has not been time enough since the beginning of the world to ring all the changes that are possible in one bell-tower. Among bell-ringers 5000 changes is a complete peal.

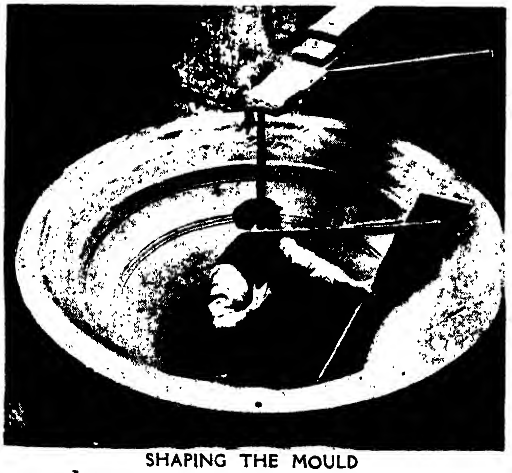
MOULDING THE SHAPE OF A BIG BELL

BUILDING UP THE CORE



THE INSIDE OF THE COMPLETED MOULD

FINISHING THE CORE



SHAPING THE MOULD

PUTTING THE MOULD OVER THE CORE

Bells are cast by pouring molten metal into a mould, with a core inside to form the shape of the bell. These pictures show the core and mould being made. First the core is made, then a false clay bell is modelled round it, and finally a mould is built up outside this. The whole is baked, and then the mould is raised, the false bell taken away, and the mould lowered again over the core ready for the molten metal to be poured in. The whole bell is built upon an iron plate covered with clay.

MELTING THE METAL FOR THE BELL

Bells are made of a mixture of copper and tin, which, after long experience, has proved to be the most suitable metal that can be used for the purpose. Here the ingots of metal are being put into the furnaces at a large bell foundry in London.

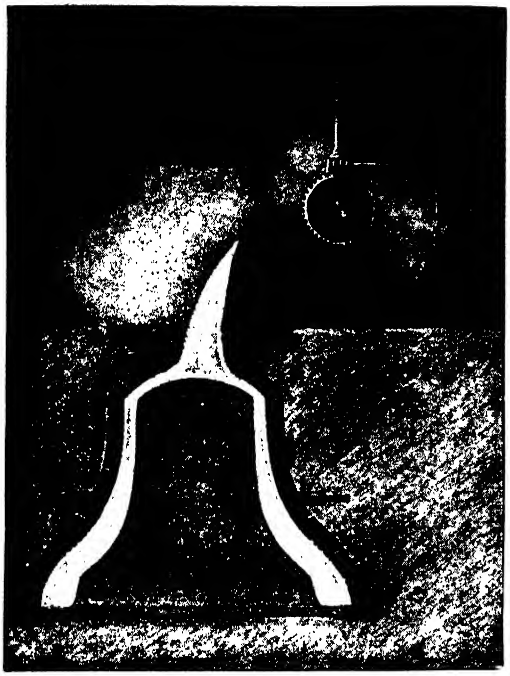
As soon as the metal is in a molten state the furnace is tapped, and the metal is run into a vessel called a ladle, which is suspended in a pit below the level of the furnace. The ladle can be moved about by great chains working on pulleys. In America bells are usually cast above ground to avoid the danger of gas explosion.

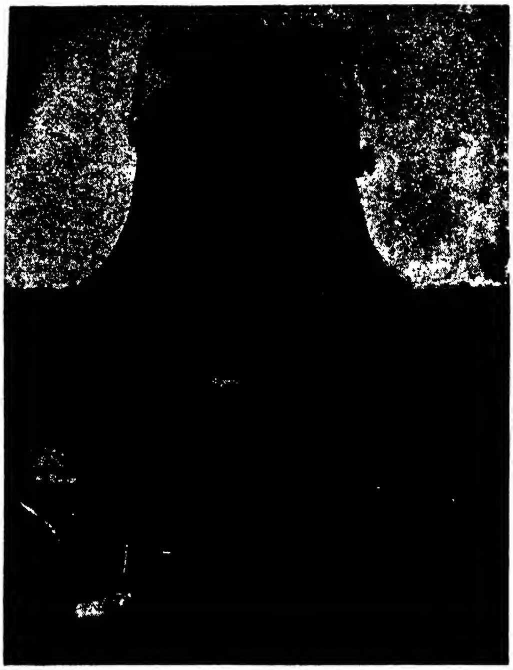
THE MOLTEN METAL RUNS INTO THE MOULD

In making very large bells the mould and core are usually arranged in a pit near the furnace, and the metal is run in direct, as shown in this picture, without being first put into a ladle. The greatest care is taken in tapping the furnace.

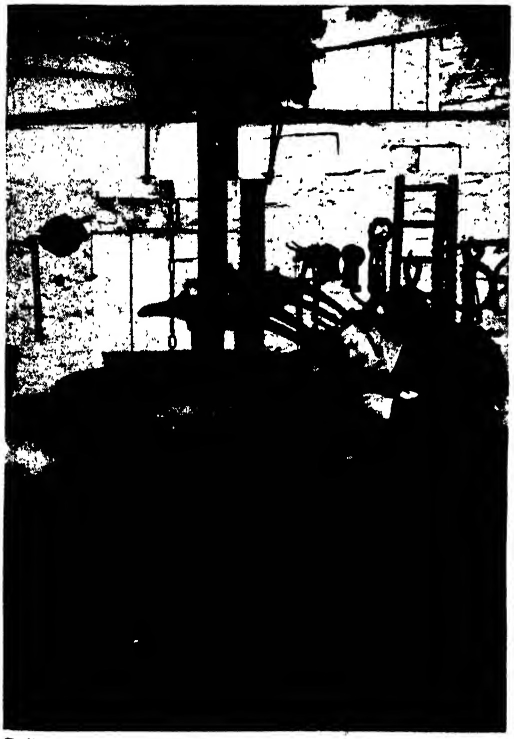
In smaller bells the metal is poured into the mould from the ladle, which is gradually tilted by means of a toothed wheel and screw worked by a handle. The details of this clever yet simple device can be seen in the diagram on the next page.

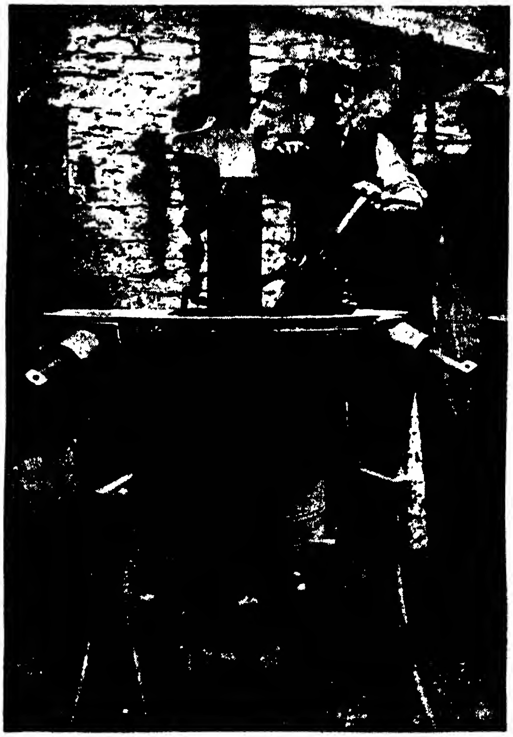
THE BELL IS MADE AND TUNED TO MUSIC





The diagram on the left explains how a bell is cast by pouring metal between the core and the mould. The mould of clay has an outer framework of iron perforated with holes, through which the moisture in the clay can escape when it is baked. On the right the mould is being raised after the metal has cooled, and the actual bell is shown in the pit, ready to be tuned.





Bells are so beautifully cast that they rarely need any tuning. Sometimes, however, the note is flat, and this is sharpened by reducing the thickness of the bell, as the man is doing on the right. On the left the note of a bell is being tested.

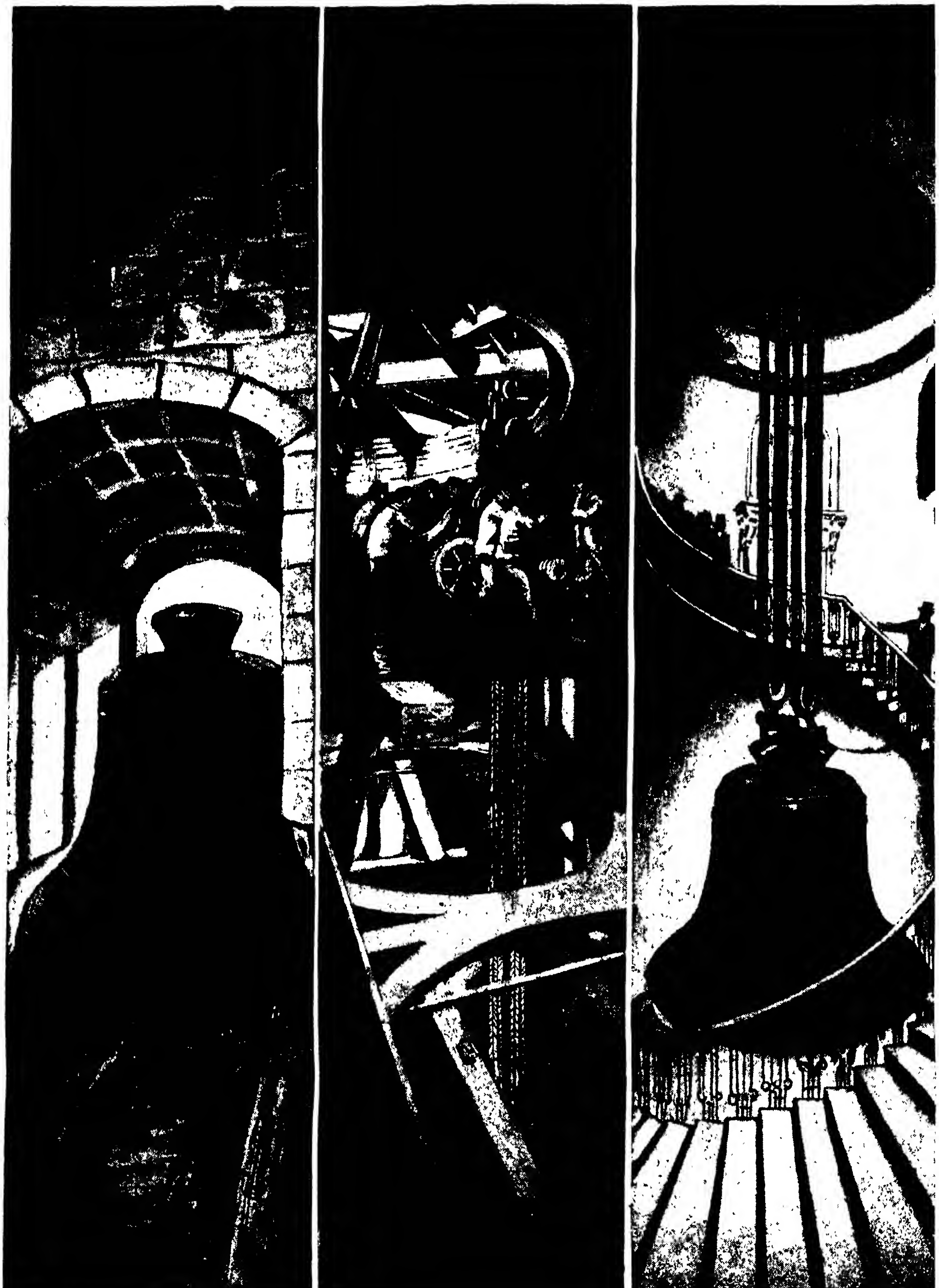
HOW GREAT PAUL REACHED ST. PAUL'S

The biggest bell in England is Great Paul, which weighs seventeen tons, and hangs in St. Paul's Cathedral. It was cast at Loughborough, in Leicestershire, and was brought to London on a great trolley, in the manner shown in this picture.

A pilot rode on a tricycle in front of the bell, and another man walked with a red flag. There was also a hut full of tools on wheels and a great tank of water for the traction-engines. Wherever the bell stopped, crowds of people gathered round.

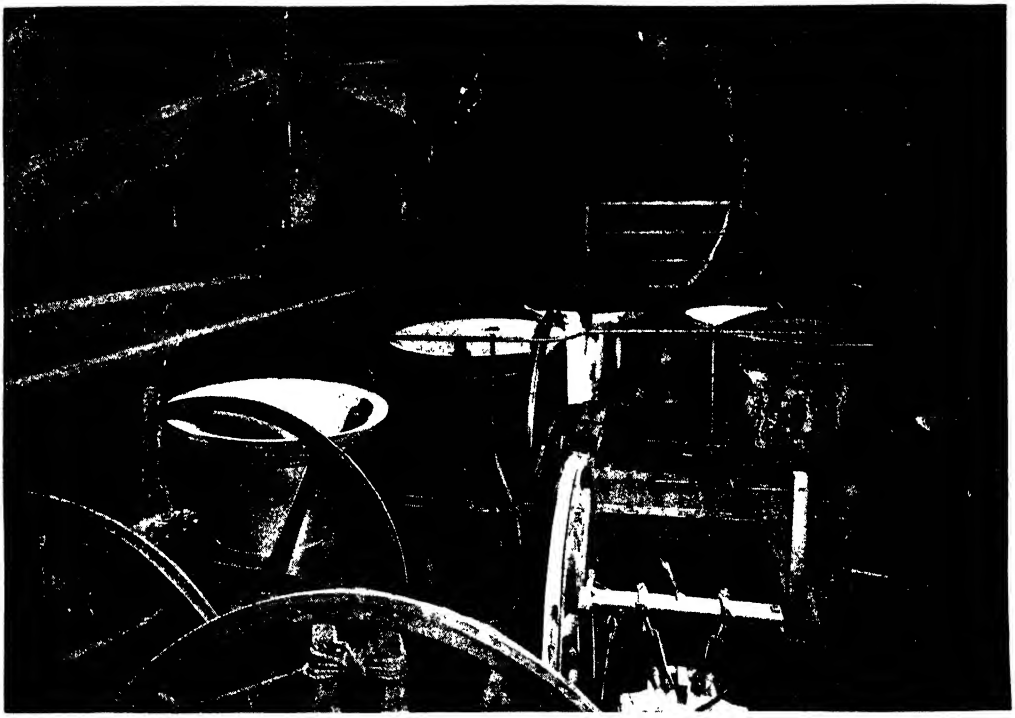
At last it reached St. Paul's, where the solid stone walls of the doorway had to be cut away for the bell to go in. It was slid to the bottom of the tower where it now hangs, along a timber-slope that had been well greased with tallow.

PUTTING GREAT PAUL IN HIS PLACE



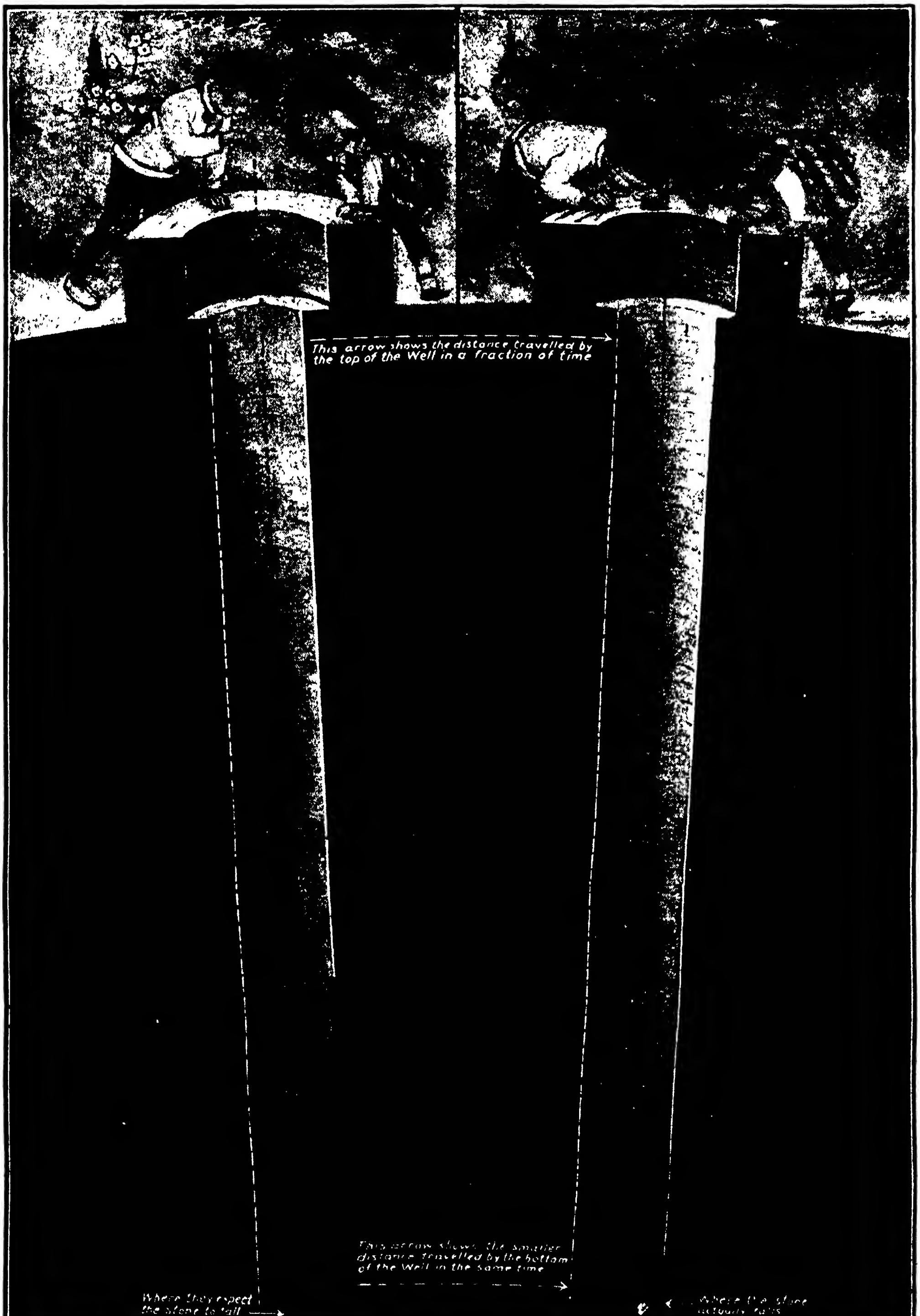
When Great Paul was landed safely at the bottom of the bell-tower of St. Paul's Cathedral, as shown on the left, a series of pulleys and winches were placed in position and the work of hoisting the bell by means of great ropes, each more than six inches round, was carried out as seen in the second and third pictures. It took no less than a day and a half to raise the great bell and the movement as it went up the tower was so slow and gradual as scarcely to be seen by the eye.

THE NEW YEAR PEAL AT ST. PAUL'S



Bell-ringing has been brought to a fine art in England. There are societies all over the country, whose members vie with each other in what is known as change-ringing—that is, the ringing of a number of bells in varying orders. Five thousand changes is reckoned a peal, and here we see the ringers of St. Paul's Cathedral ringing a peal upon the bells which are shown in the belfry above. To ring all the possible changes on 24 bells would take more than 117 billions of years.

HOW A STONE FALLS DOWN A WELL



We can never drop a stone straight down a well. The stone moves in two ways—it falls down towards the centre of the earth, but flies with the earth as well. The earth flies faster at the surface than at the centre, so that at the top of the well the stone flies with the earth more quickly than at the bottom, and these different motions affect its fall.

What You Should Know

ABOUT A PULLEY

You have often stopped for a moment, if you live in a large town, and seen some great weight—perhaps a steel safe—being raised to the top of a building.

The safe is brought through the street in a van, six or seven men slide it down to the ground on slanting beams, and a hook with pulleys is attached. Then, strange to say, although seven or eight men are required to move it on the level, two are able to pull it up to the third or fourth floor window.

What is the secret? How is it that two men are able to raise such an enormous weight so easily? The solution lies in what is known as a tackle of pulleys, and by its means a comparatively small force will do a great deal of work.

The pulley is one of the most important of the simple mechanical devices that have been invented by men and adapted to modern engineering purposes. Without its aid in lifting and moving great masses of metal, it is doubtful if any engineering shop could continue to exist. By its means men are able to handle quite easily very heavy objects that have to be moved from place to place, and a few men can do what without the pulley would require a crowd of men.

The simplest kind of pulley may be seen at the top of a clothes-line. When the laundrymaid wishes to raise the line, what does she do? She could get a step-ladder and, going to the top of the post, pull the line up from above; but she does not do that. She saves herself the trouble by making use of a pulley, a wheel with a grooved rim that rotates about an axis fixed in a frame or block. The clothes-line is passed over the wheel, and the maid stands on the ground and pulls the rope down, with the result that the clothes-line goes up.

THE PROBLEM OF THE SAFE

It would take 12 men to lift this safe, but two can raise it to the upper window. How can they do it?

This simple form of pulley does not give her any mechanical advantage—that is, it does not save her exerting the same amount of force that she would have to exert if she went up the ladder and pulled the line from above. But it *changes the direction of the pull*, so that she can remain on the ground and raise the line. Sometimes a number of fixed pulleys are used to change the direction of the pull more than once, as shown in the picture of a horse raising a weight into the air by pulling on the level.

A single fixed pulley really acts as a lever, and the effect of such a pulley is merely to change the direction of the pull for convenience. In such a pulley the whole of the weight on one side must be balanced by a corresponding weight on the other, and to move one pound on a single fixed pulley we must give a one-pound pull—or really

a little more--because we have friction to deal with. In whatever is said here about pulleys we must remember that there is always inevitably a little loss through friction.

Let us realise quite clearly that the simplest form of pulley merely *changes the direction of the pull.* Even that is clearly an enormous advantage ; anybody can see that it is easier to raise a weight by standing on the ground and pulling the rope downwards than by leaning from a window and pulling the rope upwards. But men have learned to get much more value out of a pulley than mere change of direction. The pulley has become one of the greatest helps to man because it enables him to do difficult things easily, and just as the simple pulley makes the pull easy, so other kinds of pulleys work by *splitting up the weight a man has to raise.* The principle of the pulley is simply this—that it is easier to carry 10 pounds 20 yards than to carry 20 pounds 10 yards. It is easier to carry a small weight a long way than to carry a great weight a short way.

Let us imagine a boy who has to move a sack of potatoes from the garden to his home. We will say he has to go 100 yards. Perhaps the sack is bigger than himself, and he cannot lift it. Well, he has probably read the fable of the bundle of sticks. The man could not break them all at once, but by untying the bundle he could easily break them singly. So our little man, though he cannot carry the sack of potatoes, can get six smaller sacks and distribute the weight. He has to go six times as far, but he carries one-sixth of the weight each time. Instead of taking a big sack of potatoes 100 yards, he takes six little sacks 100 yards each, travelling altogether 600 yards, and never carrying more than one little sack at a time. He has put forth exactly the same energy, but he has taken longer over it and done it without breaking his back.

That is what the pulley does for us. You see a great safe on the pavement which it would take a dozen men to lift, and it seems impossible that that huge weight could be split up like potatoes in a sack ; but it is one

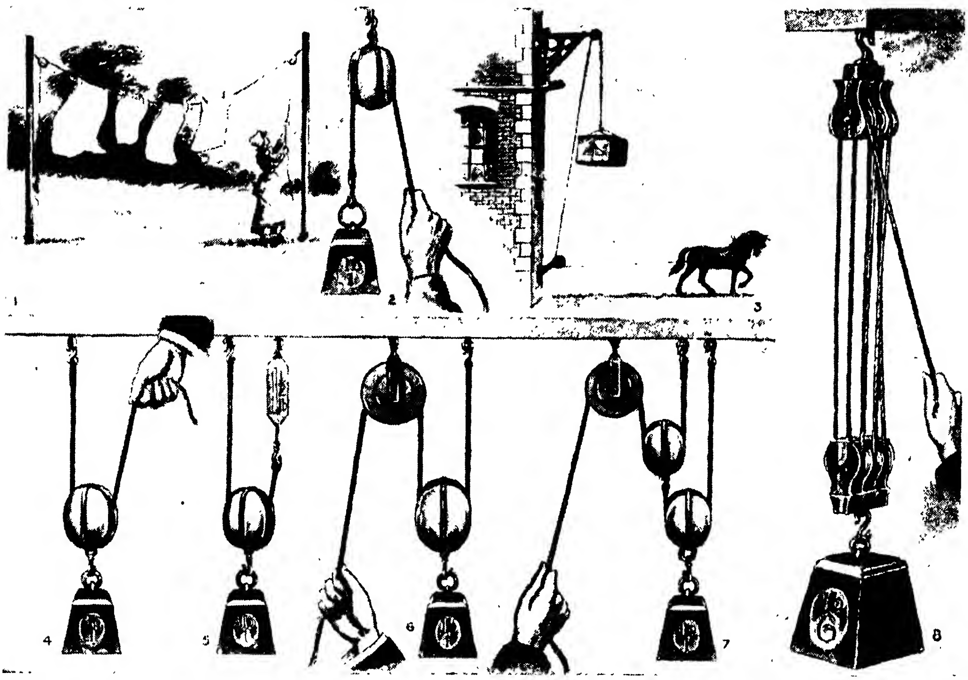
THE LITTLE BOY AND THE BIG SACK OF POTATOES

This boy has to carry this sack of potatoes 100 yards, but it is too heavy for him. How can he do it?

He divides the sack into six little sacks, he goes 100 yards six times. He divides his weight and multiplies his distance.

of the impossible things that men have done by using Nature's laws.

We cannot cut the safe into pieces and divide it as we do the potatoes, but we can distribute the strain by letting it rest in several places instead of one. It is easier for two men than for one man to lift a heavy weight, because each has to lift only half the weight, and men can make pulleys with such ingenious arrangements for



HOW A PULLEY DIVIDES THE STRAIN OF A GREAT WEIGHT SO THAT MEN CAN MOVE IT EASILY

1. By using the simplest form of pulley the maid can raise the line from below instead of using steps.

2. This shows the same form of pulley as in the clothes-line.

3. The horse here is doing what the maid does with the clothes-line—changing the direction of the pull.

4 and 5. These two pictures show one movable pulley by which a pound weight is supported with a pull of half-a-pound, the strain being distributed between the rope and the hand in one case, and between the two ropes in the other.

6. One fixed and one movable pulley, in which pulling the rope two inches raises the weight one inch, thus "cutting the weight in two and taking it twice as far."

7. The double movable pulley, raising the weight one inch when the rope is pulled four inches, so easing the strain twice as much as a single movable pulley.

8. The combination pulley known as a purchase, in which the strain is borne on six ropes, so that a weight of 300 pounds can be raised with a force of 50 pounds.

distributing the weight that with the help of these pulleys one man can do the work of many by spreading it over a longer period. The pulley, that is to say, spreads out the work so that one man can do it though he takes longer over it. It is easy to understand how this happens if you think of a weight hanging from a hook in a beam. The hook is bearing the weight. Put two hooks and carry the rope from one to the other, with the weight hanging in the middle of the rope, and two hooks are bearing the weight—the stress, or pull, being the same in both ropes. The pulley is on that principle, and although a big multiple pulley may be hanging from one hook, it has a series of pulleys with ropes passing round, and each separate rope bears its share of the strain. Let us suppose that a weight of six pounds rests on a pulley with six ropes. Each rope will bear the strain of one pound, so that when you pull the rope you will pull the weight not of six pounds, but of one. Instead of pulling six pounds at one pull, you make six pulls at one pound; the weight is divided into six bits. Now, with these things clearly in our mind, let us look more closely at the pulley.

Let us fix one end of a string to a hook in a beam, pass the other end through a movable pulley-block, as shown in diagram 4,

and attach a weight to the pulley-block. We shall find that to raise this mass, roughly, only half its weight is needed. We may prove this by using a spring balance, as in picture 5. The actual power or force here required to support the weight is a little more than half.

By means of the movable pulley, therefore, we get a distinct mechanical advantage equal to about half the weight to be raised. A little thought will show us why this is. One end of the string is attached to the beam, and this supports one half of the weight suspended from the pulley. The way men of science put this is to say that the tension in the string on each side of the pulley is equal.

Now, using a single movable pulley in order to save ourselves half the work, we can at the same time use a fixed pulley to change the direction of the pull, as seen in picture 6. Here an interesting thing will be noticed. If we wish to raise the weight attached to the movable pulley one inch, it is clear that the supporting string on each side will have to be raised one inch also, which means that we shall have to pull the end of the string two inches. Let us bear this in mind, because in it is wrapped up the whole mystery of why two men can raise the heavy safe to the third or fourth storey of a building. To raise two pounds one inch, pulling with a force of one pound, we must pull the string through two inches of space. Science uses a short formula to express this truth; the scientist puts it like this: $W \times S = P \times 2S$.

W stands for weight and P for power and S for space, so that what this means is that *the weight to be raised multiplied by the space through which it is raised is equal to the power which raises it multiplied by twice the space through which it is raised.*

Put it simply in the language of the Children's Encyclopedia, and say that the weight multiplied by the distance equals the power multiplied by twice the distance. That is what the single movable pulley does —it cuts the weight in two and takes it twice as far, on the principle that it is easier to carry 10 lb. 20 yards than 20 lb. 10 yards.

We have been speaking of a single movable pulley, but let us go a step farther and use two movable pulleys as in picture 7. We see in this picture that more than half the weight is borne by the beam, because there are two ropes holding it. Think for a moment, or actually experiment with two movable pulleys if you can, and you will see that when the weight is raised one inch the upper pulley must be raised two. Remember that in reducing the weight we lengthen the distance.

Look at picture 7. We have to raise the weight one inch, and in doing so each side of the rope rises one inch. This rope is fixed to the pulley above it, so that this upper pulley must rise two inches at the same time. Each side of the rope of the upper pulley, therefore, rises two inches, so that the hand must pull the rope down four inches. By looking at this picture we can realise how the strain is distributed.

With these principles grasped, it is quite easy for us now to understand how the heavy safe is raised so easily, and to realise what a tremendous power the pulley is to man. In raising the safe the men use an apparatus known as a purchase. This is shown in picture 8, and consists of a series or combination of pulleys arranged in two blocks, the upper ones being fixed and the lower ones movable. A rope or chain passes round all the pulleys, one end being fastened to the upper block and the other end being free for pulling. In the picture the purchase has three fixed and three movable pulleys, so that there are six ropes, and by exerting a force of fifty pounds at the free end of the rope, a weight of three hundred pounds can be raised. But for every foot the 300-pound weight is raised the rope will have to be pulled through six feet, and that is the reason why, if we watch the safe going up, we shall see that, while the men are pulling the rope or chain quite rapidly, the safe is moving up very slowly.

We see, therefore, that, though the invention of the pulley is of tremendous importance and gives a great mechanical advantage, it brings with it no real gain of work. It does not give what we call motive power. It is not like steam or electricity. The pulley simply helps a man to divide the weight of a solid thing, so that a man with a pulley can do what a dozen men could not do without it. Theoretically it would be possible to make a pulley which would enable one man to lift as much as a hundred, for the pulley distributes the strain so that it can easily be borne. Nobody knows who made the first pulley, but he was one of the world's great benefactors. Without the pulley the world as we know it would be quite impossible.

HOW WE GET GAS

BRINGING LIGHT FROM THE DEPTHS OF THE EARTH

When, in reading history, we find that at a definite period of time certain forms of evil began suddenly to decrease, and a sweeter and better tone came into the life of a people, we usually look back a little to see what great teacher or preacher had lifted up his voice and turned men to higher thoughts and loftier notions.

One of these great periods of change for the better occurred in the very early part of the nineteenth century. The wickedness that seeks the darkness of the streets at night appears suddenly to have decreased in a marked degree in London and other large towns. Hitherto the streets at night had been places of danger to foot-passengers, and whoever set out on some necessary errand did so in fear and trembling as to what might happen to him before he again reached his home. But from this terrible condition of things we find that in a few years the streets became almost as safe as they are now. Who brought about this change? What outstanding preacher of righteousness wrought this magic transformation? We look for his name in vain.

Almost unique, this great step forward owed its origin to the laboratory, and not to the pulpit or the platform. It was brought about by the inventor and engineer, and not by the teacher or the preacher. It was the invention of street-lighting by coal-gas that did more to abolish crime from the open streets than all the policemen and magistrates put together. The saying that "everyone who doeth evil hateth the light, neither cometh to the light lest his deeds should be discovered," is true not only in the moral realm, where truth is the great revealing light, but also in the everyday life of the modern town. And a writer in an old magazine of 1829 fully realised this when he asked, "What has the new light of all the preachers done for the morality and order of London compared to what has been effected by gas-lighting?"

It is difficult for us in these days of light to conceive how dangerous the streets of the cities were after dark in the old days. Footpads and robbers lurked under many a gloomy arch and shadowed doorway, and two hundred years ago a journey on a winter evening from London to Kensington, only two miles from St. Paul's Cathedral, was more perilous than a trip to Mecca or Pekin would be to-day.

The streets were terribly dark, and in the City of London a law was made that everybody should put a candle out over his door at night. It is said that the letter of the law was obeyed, but the candle was not lighted. A regulation was therefore made that every householder should light the candle over his door, and this was done; but when the wind blew out the light, as it usually did, the candle was not relighted. Again the law was altered, saying that a lantern must be hung out; but as nothing was said about a candle, an empty lantern was displayed. The regulation was altered once more so that everyone was to put a candle in the lantern, but people did not light the candle. When the law said that the candle in the lantern was to be lighted, some people put out only a small piece of candle, which quickly burnt away; and at last the law had to say how long the piece of candle should be.

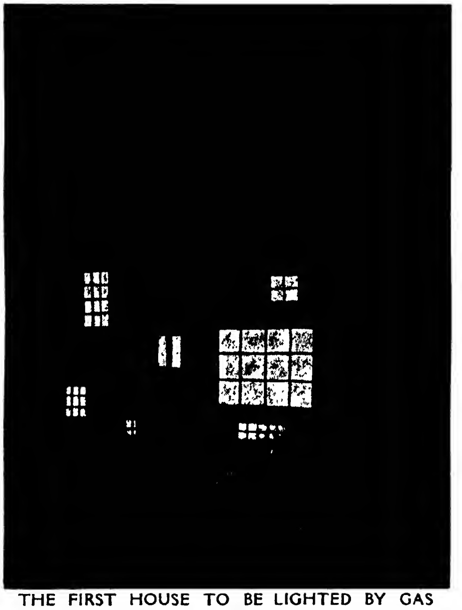
When the authorities decided to light the streets by oil-lamps it was a step in the right direction, but the flickering flames were very inadequate, and on foggy or misty nights they might almost as well have been absent for all the use they were. At last gas-lighting came, and then the whole character of city life at night was changed.

We can never be grateful enough to the men who made this boon possible. Gas is such a commonplace thing with us that we scarcely realise what the world would be without it. For lighting, for heating, for cooking, for driving machines, for making

electricity it is indispensable. Its comfort and cleanliness are beyond praise. How did the old scholars study without its genial aid ? A schoolboy can enjoy it now as he does his lessons or reads this magazine ; but Shakespeare and Sir Isaac Newton, when they wanted to read or write at night, had to struggle as best they could with a light so dim that we should despise it.

A few years ago it was thought that electricity was driving gas out of existence for lighting purposes, but by a happy accident an Austrian discovered the incandescent mantle, and many a town and district that had begun to light its streets by electricity returned to the use of gas, which, in conjunction with the mantle, gives a steady, brilliant, penetrating light.

It is curious that Dr. Johnson should have foretold the lighting of the streets by gas before such a thing was dreamt of. One evening, from the window of his house near Fleet Street, he saw the lamplighter mount his ladder and light the glimmering oil-lamp. Scarcely had he descended when the wind blew the flame out. The man went up the ladder again, and, lifting the cover of the lamp, he put his lighted torch to the dense vapour coming from the wick, which at once caught light and carried the flame to the wick. " Ah," said Dr. Johnson, " one of these days the streets of London will be lighted by smoke."



THE FIRST HOUSE TO BE LIGHTED BY GAS

William Murdock's house at Redruth, which is still lighted by coal-gas.

Coal-gas, which is really a mixture of at least eight gases, has for hundreds of years been used by the Chinese for lighting and heating. They do not seem to have made the gas, but bored down into the coal-beds, and then, as the gas escaped, conveyed it in pipes to their salt factories for use in boiling the brine. They also carried it to houses in hollow bamboo canes, closed at the ends.

In England much the same thing happened, for coal-gas often escaped above ground from the coal-beds, and was collected in bladders. Little pipes were fitted into the bladders, and the gas was burnt at the end of the tubes as required. As early as the seventeeth century coal-gas was made by an Irish dean, and in 1750 a bishop made gas and conveyed it some distance in pipes, so that it is very surprising that the use of gas for lighting was not general long before it came to be adopted.

The real pioneer in gas-lighting was a Scottish engineer named William Murdock, employed in Cornwall, who in 1792 set up a little gas-works at Redruth, and made enough gas to light his house and offices regularly. Ten years later he lighted an iron foundry at Birmingham. Murdock also made a gas-lantern to light him home at night across the moors, from the mines where he worked to his house at Redruth. He was therefore, also, a pioneer in portable gas-lighting, which has its highest development to-day in the lighting of railway trains.

The man who brought gas-lighting to London was a German named Winsor, who in 1803 lighted up the old Lyceum Theatre, and, after forming a gas company, made the experiment in street-lighting in England by illuminating one side of Pall Mall on the birthday of George III. Other streets followed, but all progress had to be made in the face of the most bitter opposition from people who should have known better.

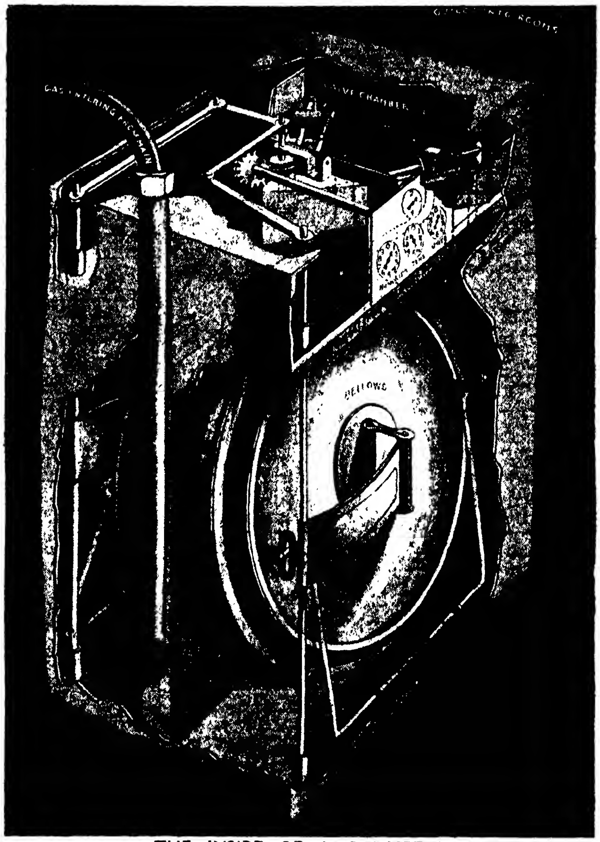
Sir Walter Scott ridiculed unmercifully the men who proposed, as he said, " to send light through the streets in pipes." Writing to a friend, he said, " There is a madman proposing to light London with—what do you think ?—why, with smoke ! " A distinguished man of science declared that men " might as well attempt to light London with a slice from the moon."

Gradually the gas made its way into domestic use, although here its progress was slow, partly because the pipes were so badly fitted in houses, and partly because the art of cleansing the gas from impurities was not understood. It smelt badly, and

often its illuminating power was poor. But in time these difficulties were overcome. The people could not at first understand that there must be a connection with the main. When a shop in the Strand was brilliantly lighted with gas, a lady offered the shopkeeper a large sum of money if he would allow her to take the lights away to her own home! When the lighting of houses by gas at last became more general, it was a long time before people could believe that the pipes did not get hot, and they could often be seen touching them very cautiously.

It was quite common, too, for the gas to be blown out, and many accidents occurred from this cause. Often people were frightened to light the burner in case there should be an explosion, and the writer of this article knows an old lady who has lived in London all her life, and who even now would just as soon go into a den of lions as light the gas, or even have gas in her house.

There are under the streets of London no fewer than four thousand miles of gas-mains, and through these pass every year about 40,000 million cubic feet of gas made from 3½ million tons of coal. Throughout the United Kingdom there are 34,000 miles of mains, nearly enough to go round the Equator and half-way back again. This is, of course, quite apart from the pipes in houses; it includes only the mains laid under the streets. Every year in the United Kingdom 15½ million tons of coal are turned into 190,000 million cubic feet of gas, which is sold for many million sovereigns. There are in the streets of the United Kingdom more than 700,000 public gas-lamps.



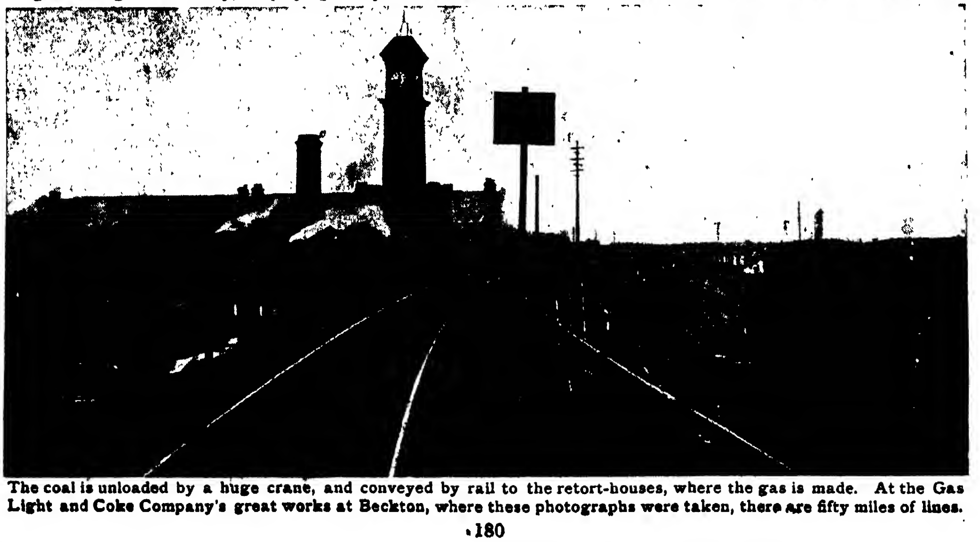
THE INSIDE OF A GAS-METER

Every gas-meter has three chambers—a valve chamber on top, and two equal chambers below with a bellows in each. Gas enters from the main and passes into the outer chamber on one side of the meter, and into the bellows on the opposite side, which, as it gets filled, presses the gas out of its chamber through the outlet into the rooms. At the same time the gas entering the other outer chamber presses the gas out of the bellows on that side. This operation goes on alternately on each side of the meter. Two slide valves in the valve chamber, worked by rods attached to the bellows, open and close the inlets and outlets of the chambers and bellows as required, and these valves also, by means of cog-wheels, turn the dial-hands.

Any boy or girl can make gas at home by filling the bowl of a clay pipe with coal-dust, covering the top with clay, and then putting the bowl in the fire between the bars. Presently a stream of dirty yellow smoke will be seen coming out of the mouth of the stem. This is the coal-gas, and if a lighted match is put to it the gas will burn. This is really how gas is made at the works, but to clean it and make it colourless and nearly odourless the gas must go through various processes. From the products of these processes, very dirty to look at, an enormous number of valuable things are made, including medicines, scents, dyes, disinfectants, oils, explosives, sulphur, ammonia, manure, and so on. The way in which the coal-tar and other refuse from the gas have been made to serve useful purposes is one of the romances of modern science. Not very long ago the gas companies found the refuse a great nuisance; they did not know how to get rid of it. Now it is a source of enormous revenue; and even if gas were no longer needed for lighting, it would be worth while to make it just for the sake of the things that are now obtained from the waste.

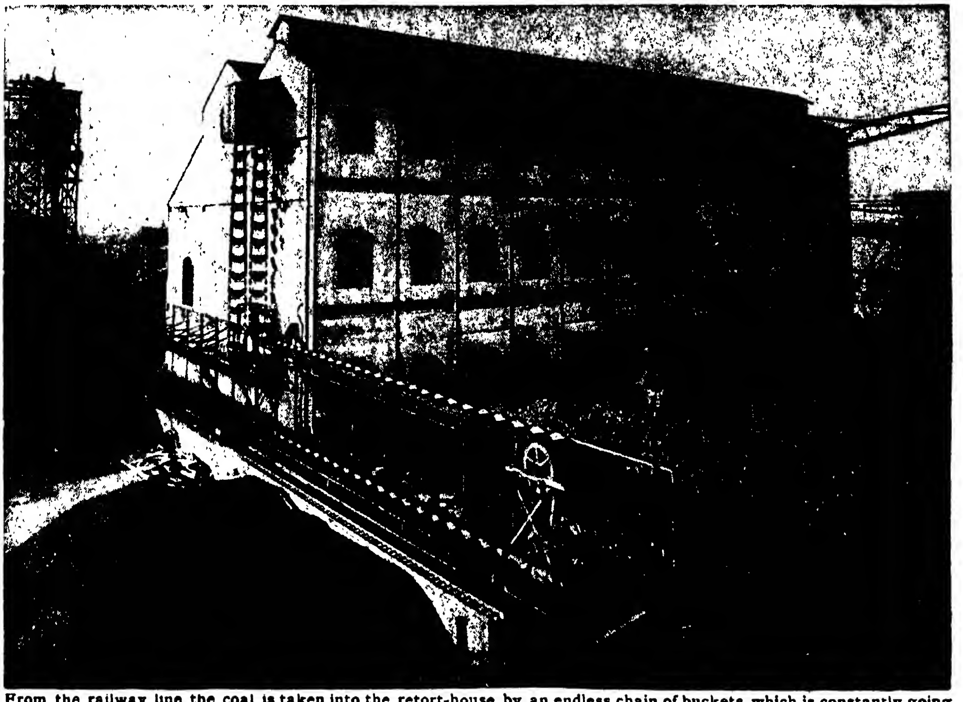
THE COAL ARRIVES AT THE GAS-WORKS

Probably no invention has done so much to counteract crime as the lighting of our streets by coal-gas. The manufacture of gas is a great industry, employing many thousands of men. Here we see the coal arriving at the gas-works.



The coal is unloaded by a huge crane, and conveyed by rail to the retort-houses, where the gas is made. At the Gas Light and Coke Company's great works at Beckton, where these photographs were taken, there are fifty miles of lines.

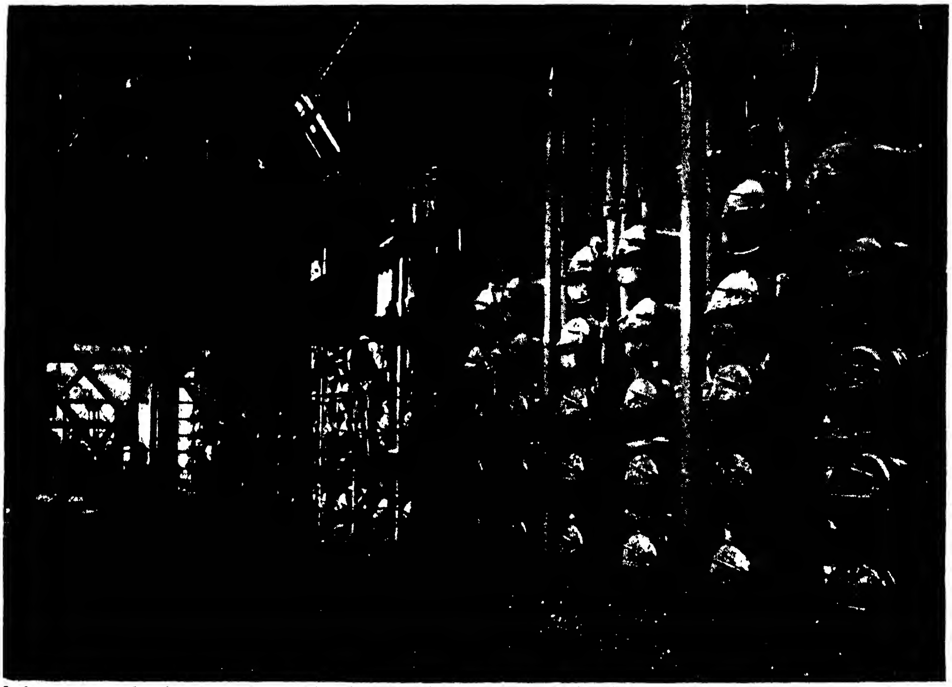
THE NEVER-ENDING CHAIN OF COAL



From the railway line the coal is taken into the retort-house by an endless chain of buckets, which is constantly going ronnd and round. These endless chains save an immense amount of hand labour, and are very rapid in their work.

Here the endless chain is seen moving across the retort-house. It pours coal into a charger, which feeds the retorts where the gas is drawn out of the coal by intense heat. On the right is the huge pipe through which the gas passes as it is made.

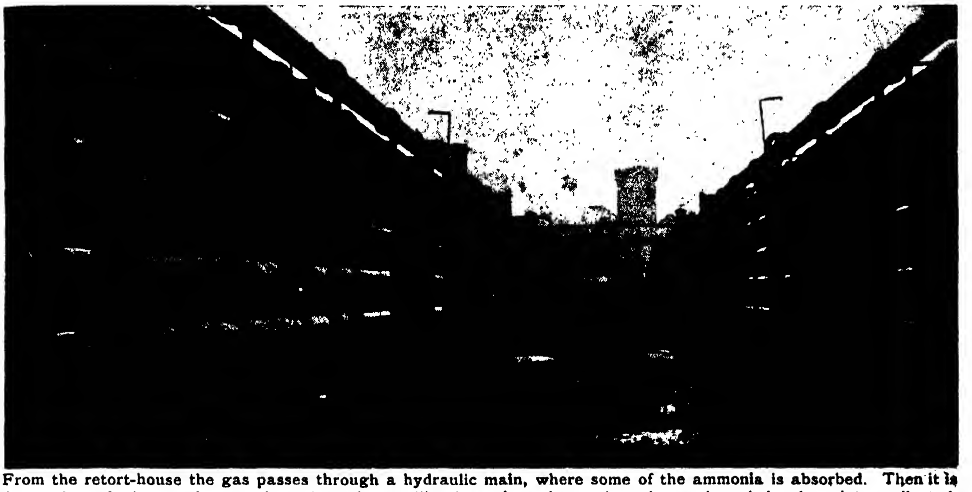
FILLING AND EMPTYING THE BIG RETORTS



In large gas-works the retorts are filled and emptied by a machine called a charger, which is worked by electricity. In this picture of the retort-house at Beckton, the largest in the world, the charger is putting the coal into the retorts.

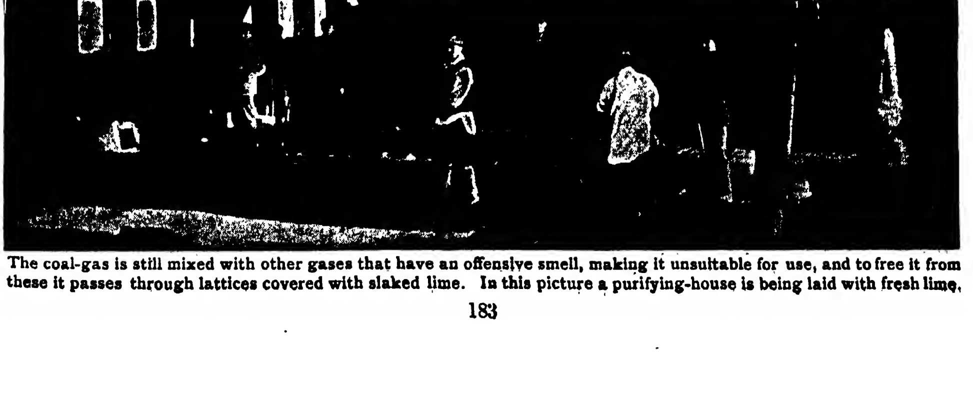
As the charger puts fresh coal into one end of a retort, it pushes the red-hot coke, from which the gas has been extracted out at the other end. The coke falls on an endless chain, and after being cooled by water is conveyed to railway trucks.

THE GAS IS WASHED AND SCRUBBED



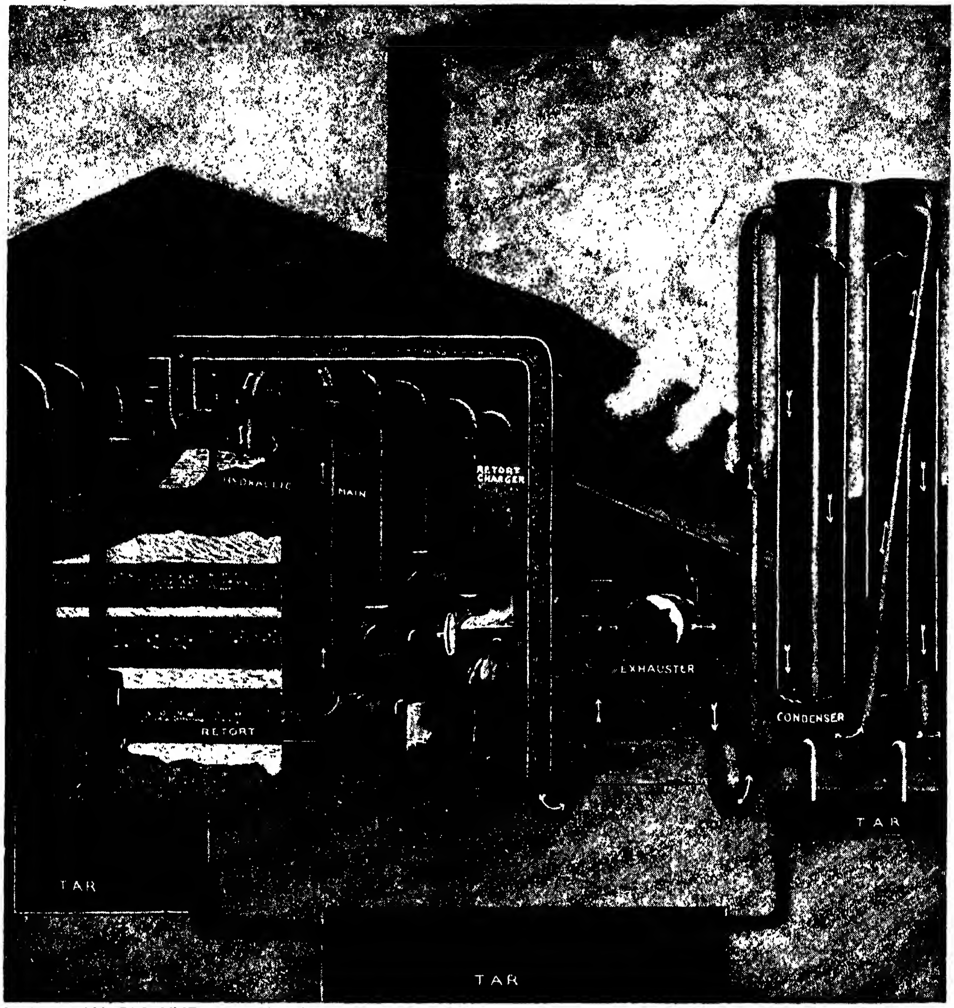
From the retort-house the gas passes through a hydraulic main, where some of the ammonia is absorbed. Then it is drawn through pipes, and passes through condensers like those shown here, where the gas is cooled and much tar collected.

The condensers may be horizontal or upright. The gas next goes into the scrubbers, where it passes through lattices, or layers of coke, while a stream of water pours down upon it, absorbing ammonia. Here men are repairing a scrubber.

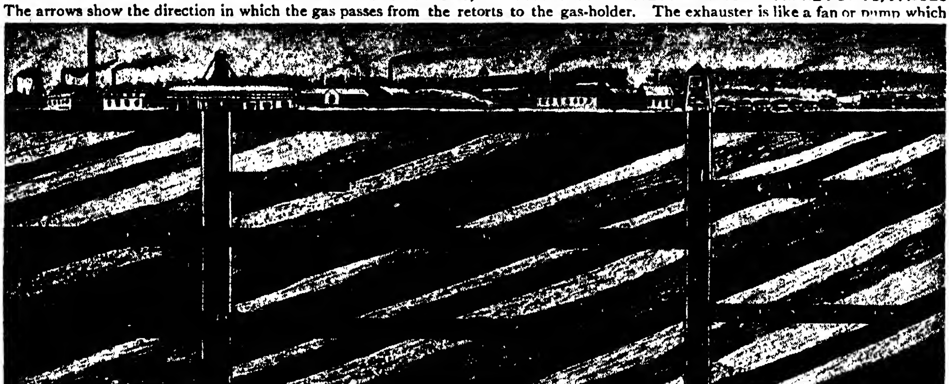


The coal-gas is still mixed with other gases that have an offensive smell, making it unsuitable for use, and to free it from these it passes through lattices covered with slaked lime. In this picture a purifying-house is being laid with fresh lime.

HOW THE SUNSHINE OF MILLIONS OF

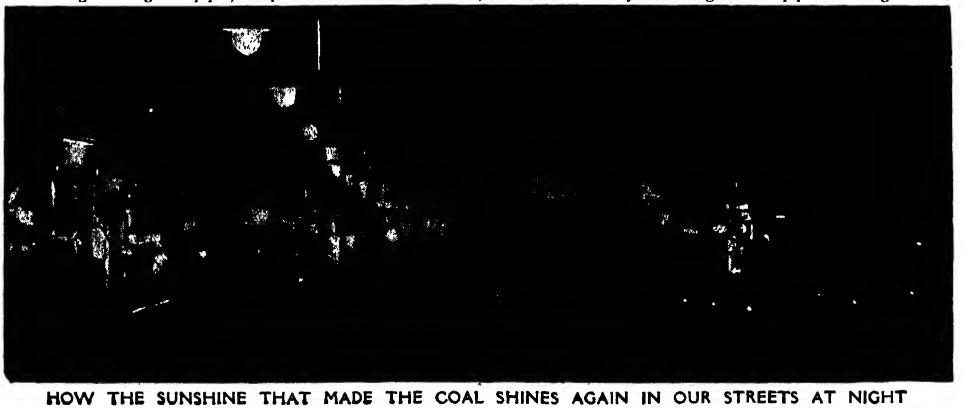


THE GAS-WORKS WHERE THE COAL GIVES OFF ITS GAS, WHICH ENTERS THE PIPES FROM THE RETORTS, PASSES
The arrows show the direction in which the gas passes from the retorts to the gas-holder. The exhauster is like a fan or pump which



HOW WE GET THE COAL OUT OF THE EARTH, WHERE IT HAS LAIN FOR MILLIONS OF YEARS

THROUGH THE CONDENSERS AND CLEANERS, AND REACHES THE GAS-HOLDER ON ITS WAY TO OUR HOMES
draws the gas through the pipes, and passes it on to the condensers, where it is cooled by circulating round a pipe containing cool air.



HOW THE SUNSHINE THAT MADE THE COAL SHINES AGAIN IN OUR STREETS AT NIGHT

HOW A SEWING MACHINE MAKES A STITCH

These pictures show how a sewing machine works. The handle turns a bent shaft, and by a series of cams, or pieces that rotate unevenly, the revolving motion is changed into a movement up and down, or backward and forward. In this way the needle is made to go up and down, the shuttle to move to and fro, and a bar to work backwards and forwards, feeding the work to the needle. A "take-up" also makes the cotton of the needle alternately tight and loose. The three pictures below show how the cotton of the needle catches up the cotton of the shuttle to make a stitch.

What You Should Know

ABOUT A MOTOR-CAR

ONE of the greatest facts of our time has been the coming true of the magic carpet. What is there in all the magic tales more wonderful than truth? Perhaps somebody one day will begin a tale like this:

Once upon a time a man dreamed of all the impossible things, and he went to sleep for a thousand years, and woke to find his dream come true.

Or perhaps he would begin it something like this:

In the early days of the world, before men had found out how to do things, they could only dream them; and they told their dreams and fancies one to another. They filled the world with visions, like the vision of the magic carpet that took you anywhere, the magic wand that changed you into anything, the magic touch that would make the very stones cry out. And as the world went on, and men found out the way to do things, these visions all came true, and history has been the coming true of dreams.

There certainly will be a tale beginning like that some day, and may you and I be here to read it!

We must know something about most things if we would know all about a motor-car. The history of it, even while it was slowly shaping, and long before it assumed any definite shape, would take us back hundreds of years. The geography of it, the source of all the things that make it up, would take us round the world. The chemistry of it, the wonderful story of the little specks of oil that drive it and the electric spark that sets up its great explosions, would fill a book. The physics of it, the laws by which its thousands of pieces all hold together and play their perfect part, are astonishing to think of. The biography of it, all the men who have put little bits into it for years and years, some of them knowing and some not knowing that they were doing it, would bring in more names than we can stop to mention. A simple thing it has come to seem at last, but perhaps it is because we take it all for granted, and do not bother our heads about the mystery.

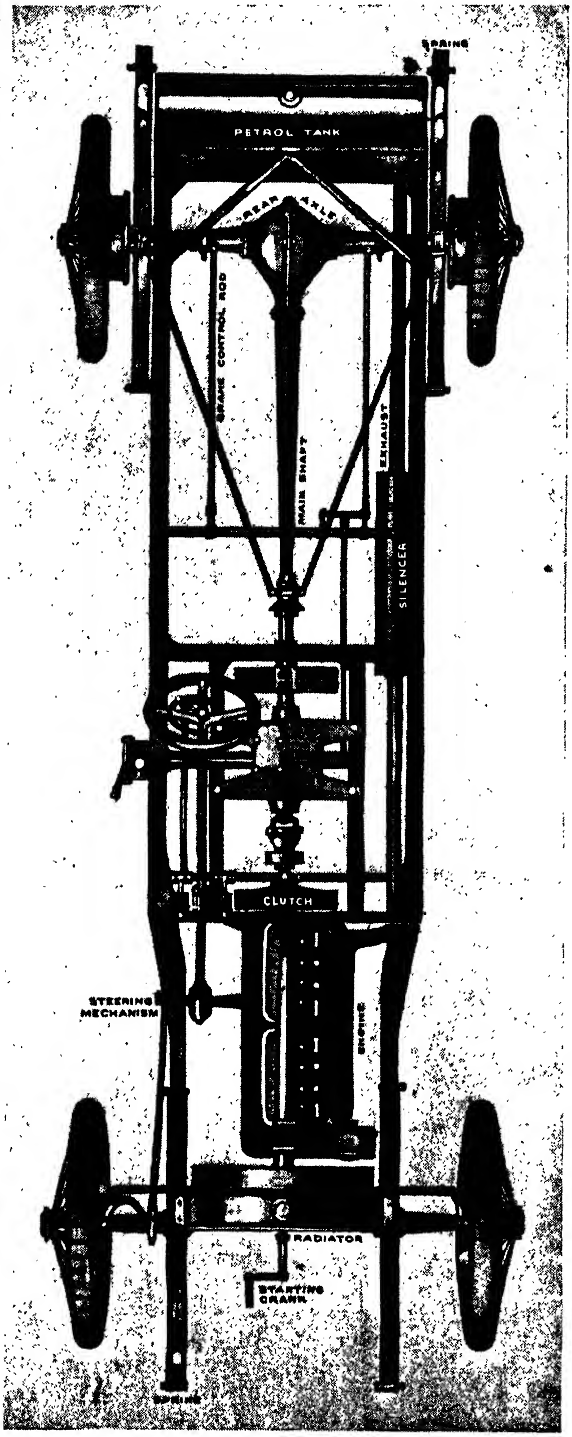
That is the story of most things, if we think of it; there is always a mystery, and we put it away conveniently, and deal with what we see. So we will do here in these pictures that are to help us to understand the working of a car. We have nothing to do with the skill of making it, of bringing together the thousands of parts, all fitting perfectly and working in unison to the tenth of a second of time. We have simply to take this marvel as it stands, as the workshop turns it out, and to see what makes it go, and how it works. We are to get inside the engine, to see what happens when the driver turns the crank, takes his seat, and begins to work his levers.

We shall see the marvellous mechanisms that carry the driving power, that bear the strains and stresses that are always changing, the simple devices that open and shut the doors of many chambers, the complicated and very puzzling things that regulate the speed; and we shall see how a drop of petrol, pumped up from the earth in the East, comes out of a little tank and runs through various pipes in wondrous ways until it sets these things in motion, and sends the great steel marvel dashing through our streets. Strange that such a new wonder as the motor-car should rest on one of the oldest mysteries in the world—a drop of petrol; but not so strange, perhaps, when we think of it, for new and old are always meeting, and the new is the application of the old. Is there anything new under the sun? If there is it is chiefly new ways of using old things or applying old truths.

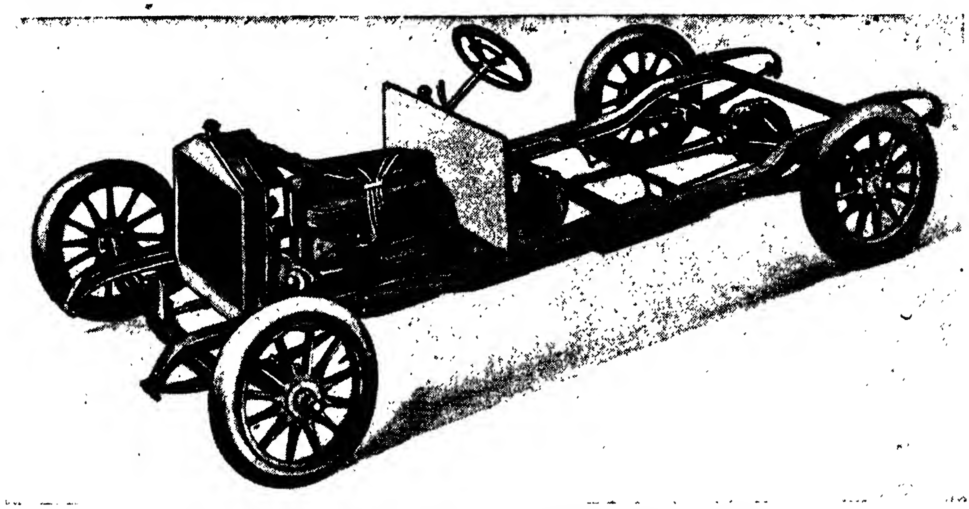
There is no limit to the new things men can make from old things; and, after all, that is how men make a motor-car. They take some of the

oldest things in the world and put them together in new ways; they touch them with the magic wand of knowledge and bring out their magic powers; and, lo! we have our magic carpet which will take us almost anywhere — if only you can get a chauffeur and a drop of petrol! Let us look at the pictures, and carefully follow the explanations with them.

1. In this picture we see the chassis of a motor-car from above. We see the crank with which the driver starts the engine — the exasperating handle, which for many years has been the most humiliating feature of a motor-car, but is now, happily, disappearing with the coming of the self-starting engine, which a child may set going by moving a switch. Above the crank is the radiator, and behind is the engine with its cylinders, the wonderful carburetter, the magneto, and all those ingenious attachments which make it possible to run a car at a mile a minute, if need be, and to have it under absolute control. Beside the engine is the steering mechanism, the simple but ingenious instrument upon which so many lives depend every day in our streets; and beyond is the gear-box, which controls and adjusts the power of the engine to changing conditions, such as, for instance, the climbing uphill. Continuing from these runs the main shaft, which has the greatest burden of a car to carry, ending in the rear axle, and on both sides are the rods that control the back brakes. On the right is shown the exhaust pipe for carrying off the used-up gases, with the silencer for reducing the noise of the explosion, and at the extreme end of the car is the petrol-tank — the little tank into which, when we are wise, we shall pour our alcohol to drive our cars and be a blessing, instead of letting it ruin our people and be a curse. At each end of the car on both sides are the springs that carry the body of the car, softening the vibration, which would otherwise make riding very unpleasant and shorten the life of the car.

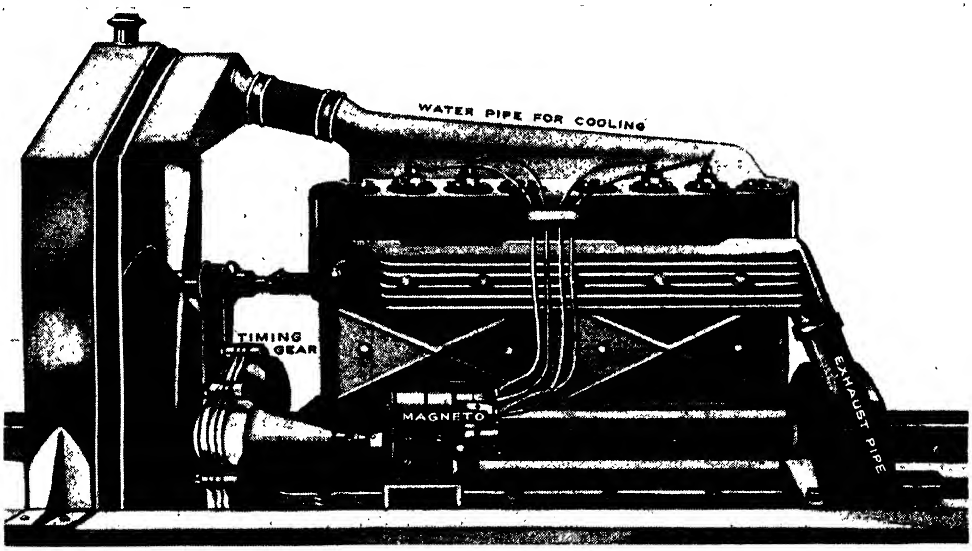


1. LOOKING DOWN ON THE CHASSIS



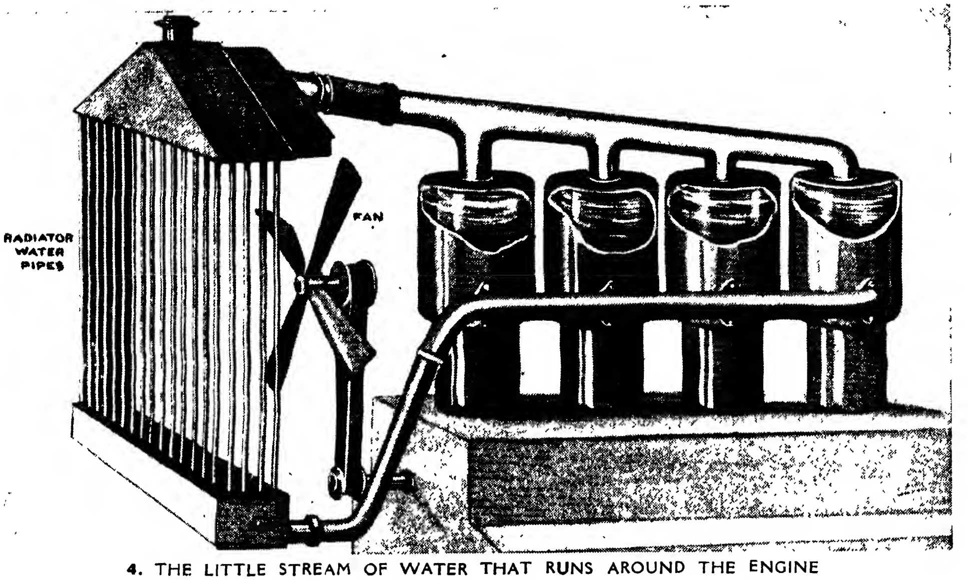
2. THE CHASSIS THAT CARRIES THE ENGINE AND THE CAR

2. The chassis—the French word which we are all familiar with now—is, of course, the steel framework of the motor-car, upon which the body rests. It is made up of two very strong steel bars, held fast by cross-bars. It is quite clear that the chassis must be of tremendous strength, for it carries the whole weight of the engine and the car, and is subject to all the stresses and strains that a motor-car must bear. It carries, first, the front axle with the two front wheels, and, above and behind this axle, the radiator and the engine. Then come the clutch, the driving-control, gear-box, and the precious rear axle carrying the all-important driving-wheels.



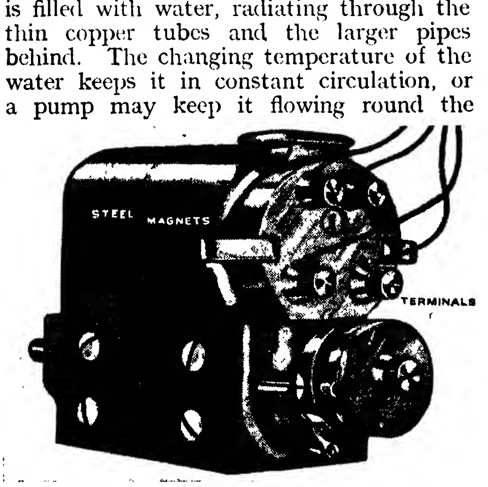
3. THE MARVELLOUS POWER-HOUSE OF A MOTOR-CAR

3. This is the house of power, the massive engine containing the cylinders. We see the magneto and the four wires that lead to the electric sparking-plugs, the exhaust pipe that carries off the used gases, and the fly-wheel that carries round the clutch. We see the case containing the timing gear that regulates the valves and magneto, and the water-pipe through which water circulates to save the engine from getting red hot.



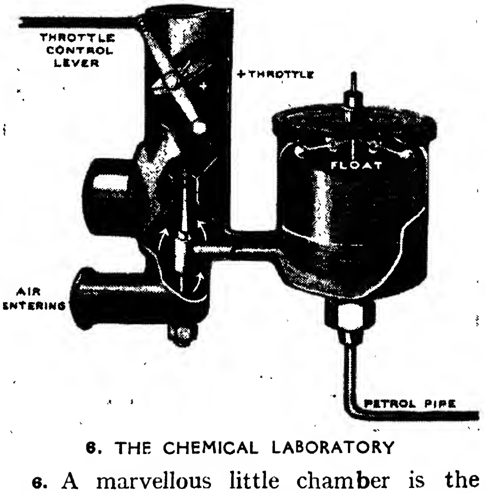
4. THE LITTLE STREAM OF WATER THAT RUNS AROUND THE ENGINE

4. We need little imagination to see the danger of a red-hot engine, and the radiator is filled with water, radiating through the thin copper tubes and the larger pipes behind. The changing temperature of the water keeps it in constant circulation, or a pump may keep it flowing round the cylinder jackets back to the radiator, where a revolving fan draws in cold air around the tubes. In spite of these cooling arrangements it is difficult enough to keep the water cool, but without them the engine would be so hot that the pistons would expand in the cylinders and refuse to work.



5. THE LITTLE MAGNETO

5. The magneto consists of two or three domed steel magnets. Within the dome an armature—a soft iron core, wrapped in insulated wire—revolves upon a spindle. As it spins, the armature is magnetised by the magnets, and generates an electric current. This flows through four terminals along wires. Each wire ends in a sparking-plug screwed into a cylinder. When we turn the starting-handle of the car the armature rotates, sends its current along the wires, causes a spark and an explosion in each cylinder in turn, and so starts the engine.

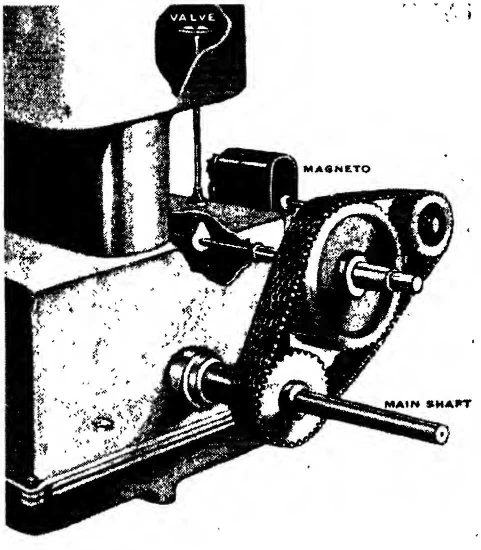


6. THE CHEMICAL LABORATORY

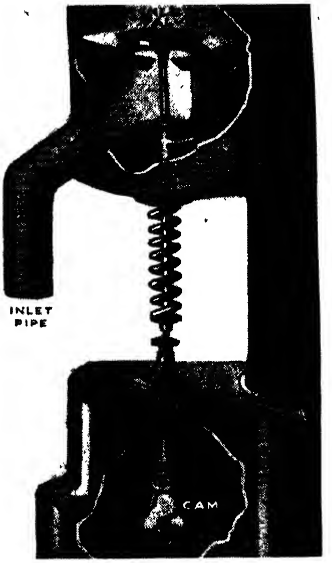
6. A marvellous little chamber is the carburetter, where the explosive mixture of air and vaporised petrol is made which is to meet the spark from the magneto and explode just in time to drive the piston down and work the engine. It is really a double chamber, one containing a metal float to regulate the flow of petrol. When the float sinks it opens a small valve and

allows the petrol to flow in till the rising of the float on the fluid automatically closes the valve. From the float-chamber runs a tube, bent upwards to form a jet. A metal funnel at the side, known as the "choke-tube," admits air from the atmosphere, and by an ingenious arrangement the downstroke of the piston causes an inrush of air through the choke-tube. The petrol from the float-chamber forms a jet in the carburetter, the inrushing air mixes with it, and the explosive mixture is prepared, and is sucked upwards to the cylinder through the inlet pipe shown in picture 8. The quantity admitted to the cylinders is regulated by the throttle.

8. Here we have a close view of the valve shown in picture 7, and of the cam that works it. The cam is seen in the act of opening the valve. Clearly, if the valve-rod rested on a perfectly circular shaft, the revolution of the shaft would leave the rod in exactly the same position all the time. The purpose of a cam is to change the position of whatever rests upon it, and this is accomplished by the cam's irregular shape. In this case it is pear-shaped, so that, as the cam-shaft revolves, the point of the cam comes up on top with each revolution. In this position the cam, of course, lifts the valve-rod higher, and the rod, in rising, opens the valve. As the



7. THE "CLOCKS" THAT KEEP THE TIME EOR A MOTOR-CAR.

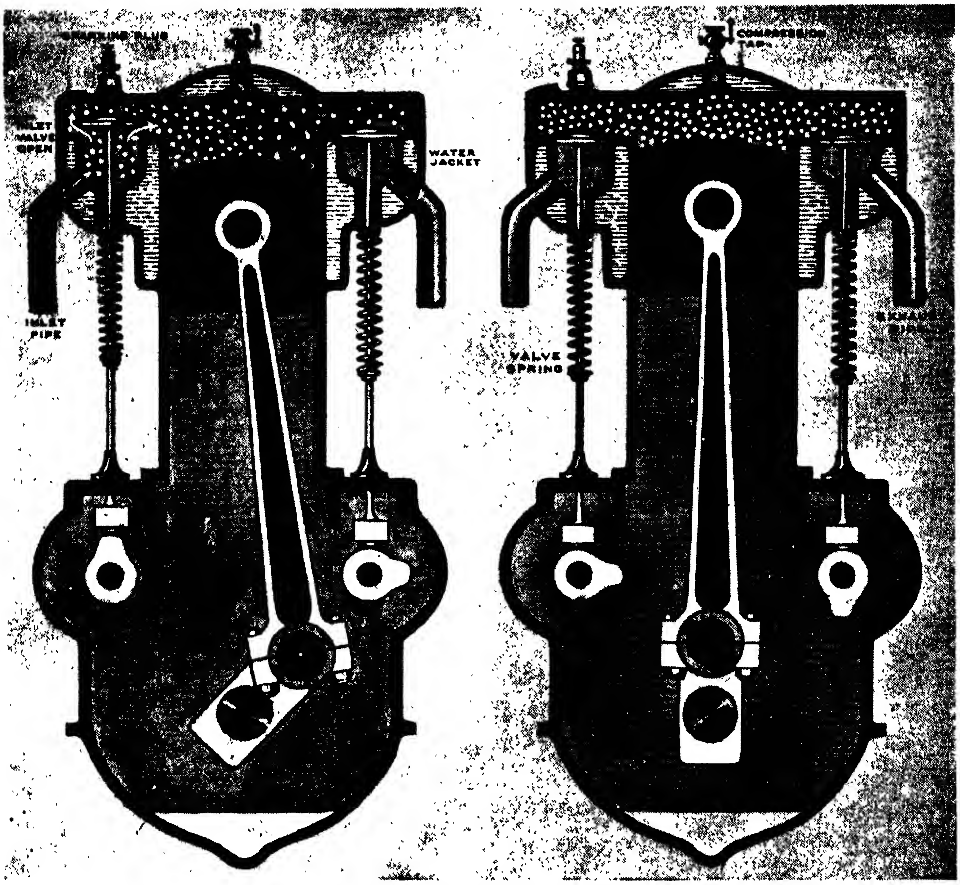


8. THE LITTLE DOORS THAT OPEN AND SHUT

"pear" cam goes round, the rod, helped by a spring, slides down with it, and as it falls the valve closes.

7. Time is everything in a motor-car; things must happen at the right moment, neither early nor late. The working of the valves is of the highest importance; they must open and close on the precise moment of time. It is all arranged by a wonderful series of cams and cogs and chains, as seen in this picture. The chain-band passing over the three cog-wheels, of varying sizes, revolves with the crank-shaft, and, of course, carries round the other wheels at different speeds. The small wheel carries round the coil in the magneto; the large wheel regulates the valves. The revolving shaft of this large wheel regulates the rise and fall of the cams, which, in turn, regulate the opening and shutting of the valves.

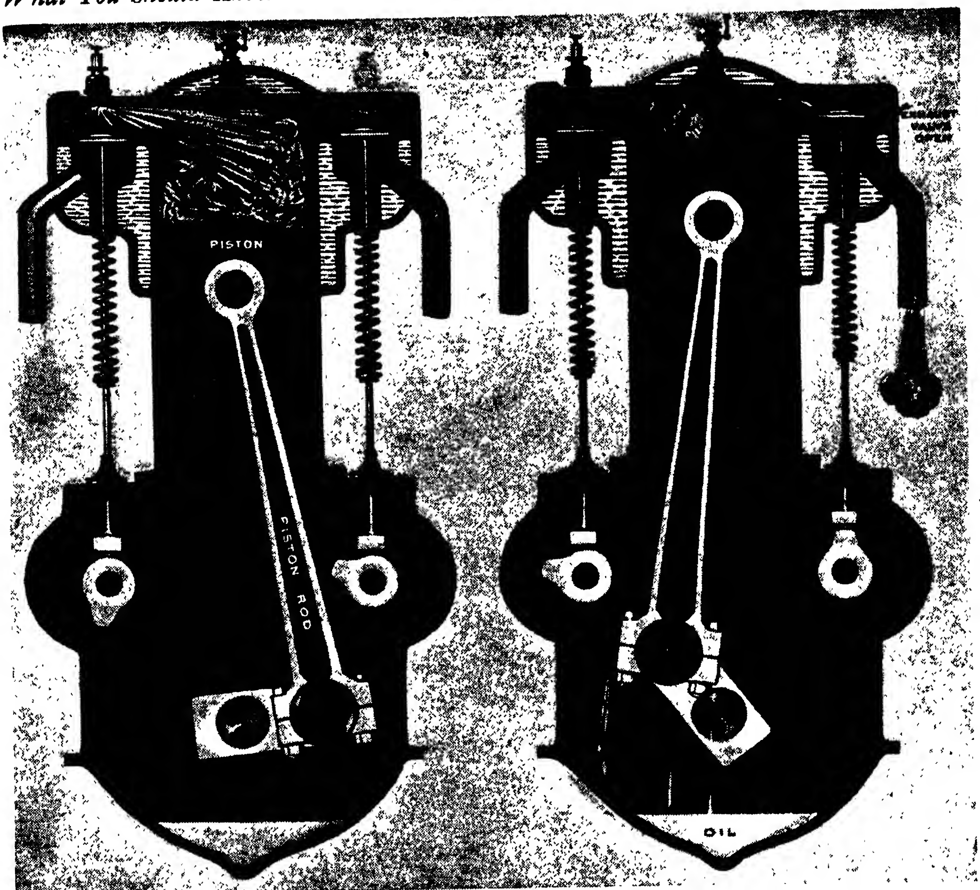
9. We now come to see what happens inside the cylinder. Of course, the engine of the motor-car which we are studying possesses four cylinders, within each of which occurs the same series of operations, and their four piston-rods contribute equally to the turning of the main shaft which eventually turns the back wheels. The four drawings on these two pages represent one cylinder opened up in such a way as to display most clearly what happens within it. In passing we should notice how the water-jacket, through which circulates the water cooled in the radiator, surrounds the part of the cylinder in which the



9. THE CYLINDER OF THE MOTOR-CAR AND THE FOUR

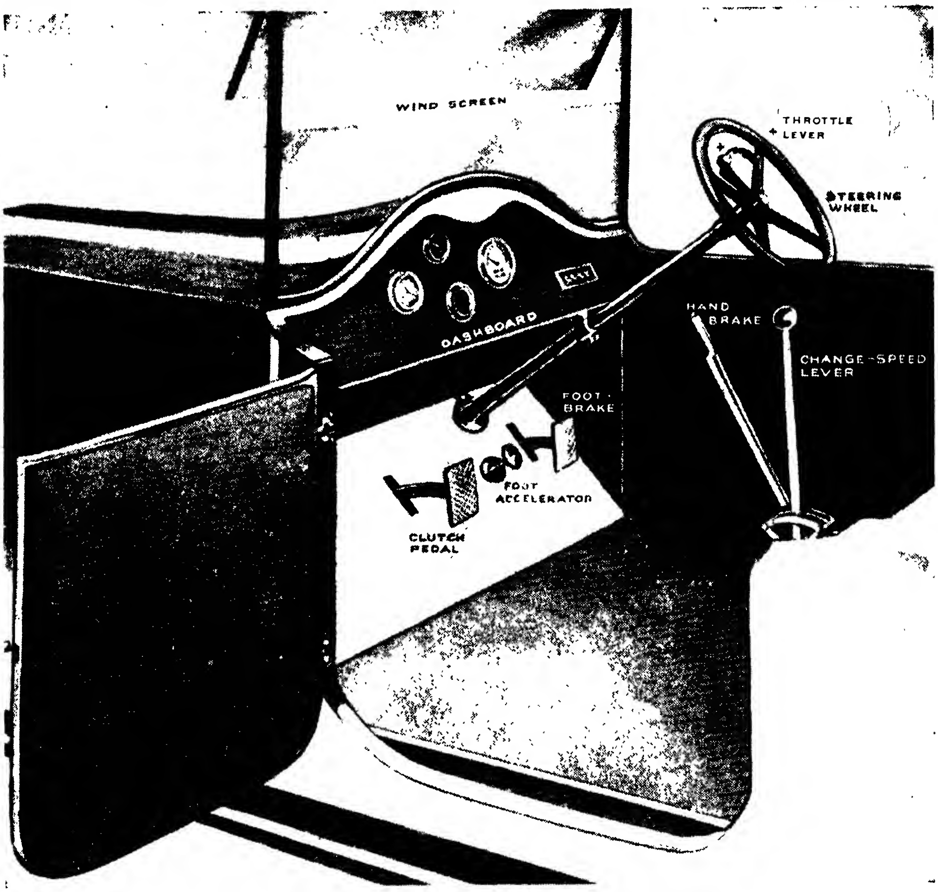
explosion occurs. Let us begin with the first stroke of the piston. As it descends in the cylinder it leaves a partial vacuum in its place, but simultaneously the little valve, which we may regard as the front door of the cylinder, opens by the working of a cam, and up through the inlet pipe there comes rushing in a mixture of air and petrol. It has been mixed, as we have seen, down in the carburetter, with which the inlet pipe is connected. As the piston-rod goes down the valve of the inlet port opens to allow the mixture formed in the carburetter to pass into the cylinder. The valve closes and the chamber is airtight. Now the piston flies back, but it flies back not into a vacuum, but into a field of gas, which it compresses in the head of the cylinder. Its downward " inlet " stroke lets in the mixture of air and petrol ; its upward compression stroke compresses the mixture to about one quarter of its original space. The great moment for the motor-car has now arrived. The chemical laboratory, which we call the carburetter, has prepared the stuff for the explosion. The shafts and rods and cogs and cams have kept time well, and brought the explosive substance into the explosion chamber, and have sealed both doors, or valves, so that the gaseous mixture cannot escape. We are now waiting only for a spark, and we shall see what happens.

What does happen is seen in the first picture on the next page. The magneto is ready, and waiting for the moment when the doors of the explosion chamber are sealed fast. The electric current generated by the revolving coil between the magnets travels along the wire which runs from the magneto to the sparking-plug at the top of each cylinder, and on reaching the plug it is made to cause a spark in the explosion chamber, full of compressed air and petrol. There is a tremendous explosion. There is only an



STROKES OF THE PISTON-ROD THAT MAKE THE ENGINE GO

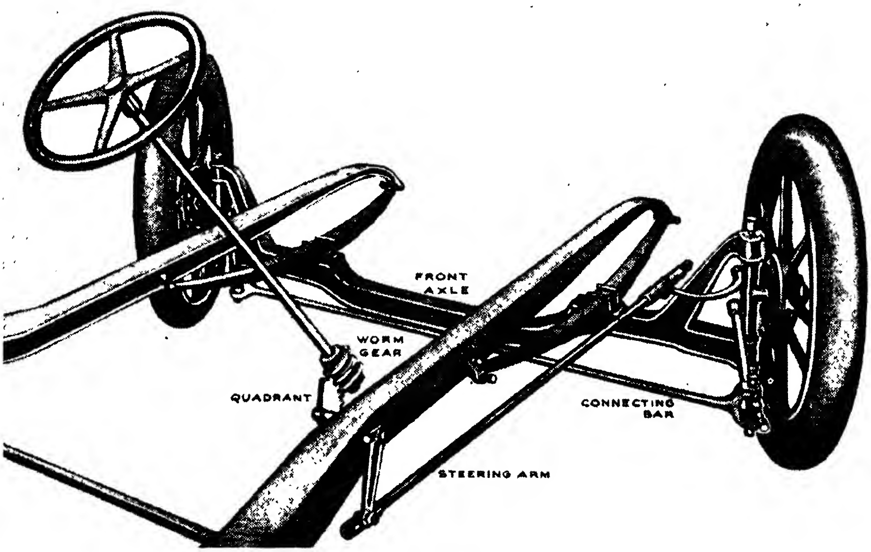
inch or two of space in this little chamber, but a great scientist has told us that if an atom were to break in two its power would be great enough to smash a continent, and the power of the explosion in the sealed chamber is terrific. It drives down the piston as fast as it can go—the very thing it is meant to do. The piston is connected by a vertical piston-rod to a horizontal crank-shaft, out of sight in the base-chamber. The descending piston-rod has a rotary action. Its down-thrust makes the crank-shaft revolve, and with it the fly-wheel and clutch, and a continuation of the shaft, bearing cogged wheels, in the gear-box The piston descends with enormous force vertically in the cylinder. The piston-rod rotates with the crank-shaft to which it transmits power, goes down and round, and is then thrust upward, carrying the piston back for an important duty. The cylinder is now full of foul, expanded gas. But the cam-shaft keeps punctually revolving, and now, as the piston rises, up comes the top of the cam, beneath the stem of the exhaust-valve. This valve is forced up and a way is opened out of the cylinder. The piston ascends and thrusts the foul, scorching gas out of the chamber. The gas passes on into the silencer, cooling and expanding, so that it puffs out noiselessly from the exhaust-pipe at the rear of the car. By this time the exhaust-valve has returned to its place, the inlet valve is opened, and the descending piston is drawing in another charge of explosive vapour. We have now seen how the gas comes into the cylinder by the front door, how both doors are sealed while it is compressed and exploded, and how the back door opens instantly for the foul gas to leave. So this vital work goes on, hundreds of times a minute, driving the piston-rod as fast as it can go, and driving with it the motor-car.



10. THE HANDS AND FEET AND EYES OF THE MOTORMAN

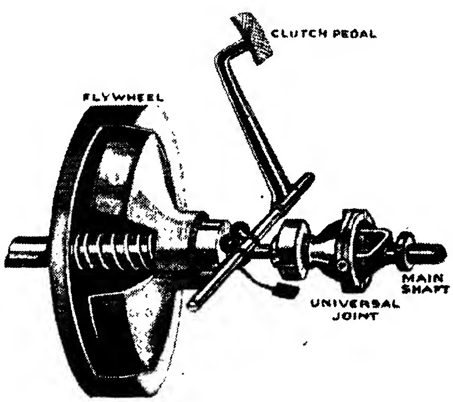
10. The man who drives a motor-car must think of nothing else. He has enough to do. His hands and feet are instantly ready and alert, and his attention should never be off the appliances on which the safety of the car depends. He has before him, as he sits in his seat, the steering-wheel, the lever for changing speed, the brakes, the delicate mechanisms for accelerating the flow of petrol, and the pedal controlling the clutch. It is enough for any man to do with the lives of many people in his hands. There are two brakes—one worked by hand and one by the foot. The foot brake works direct on the brake-drum, just behind the gear-box, and slows down the speed of the transmission or driving shaft, which, in turn, slows down the driving-wheel. This brake is for momentary use. The hand brake is for permanent stoppages, acting directly on the back wheels. The change-speed lever for working the gears is moved backwards and forwards in and out of slots, effecting changes of speed by engaging cog-wheels of various sizes. The clutch pedal is a simple but very important instrument. As it is shown here the clutch is fixed into the interior of the fly-wheel and spins with it, but its shaft is revolving idly in the gear-box. As the picture shows, the gears are neutral ; the crank-shaft is not linked up with the shaft which drives the back or road wheels, so, although the engine is running, the car cannot move. Between the clutch and brake pedals is a foot accelerator, serving the same purpose as the throttle-lever fixed on the steering-wheel. Inside the carburetter, as we see in picture 6, is what is called a throttle, opening and shutting by the working of a lever. The throttle-lever and foot accelerator work this lever, the throttle-lever acting by a wire running inside the hollow shaft of the steering-

pillar. The throttle controls the quantity of gas to be admitted to the cylinders, and so increases or reduces the speed of the engine. When the throttle is open more petrol comes into the carburetter. There is, therefore, a bigger explosion—more driving power—and the car goes faster. The spark-lever on a steering-wheel enables the driver, by pushing it up or down, to advance or retard sparking in the explosion chamber.

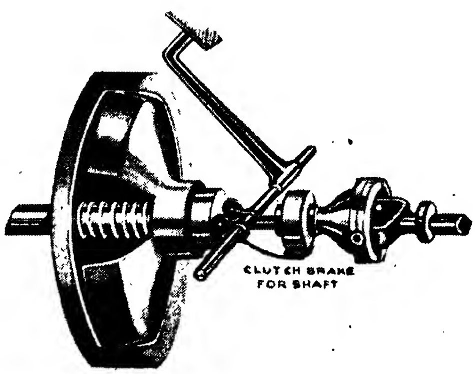


11. HOW THE DRIVER STEERS THE CAR

11. An important purpose of the front wheels of the car is steering, and this picture shows how the steering-wheel works. The end of the steering-shaft is screw-shaped, and works on what is called a "quadrant," in such a way that the steering-arm, connected with the right front wheel, responds to every movement. The connecting bar between the two wheels carries the action of the right wheel to the left, and so the car turns.



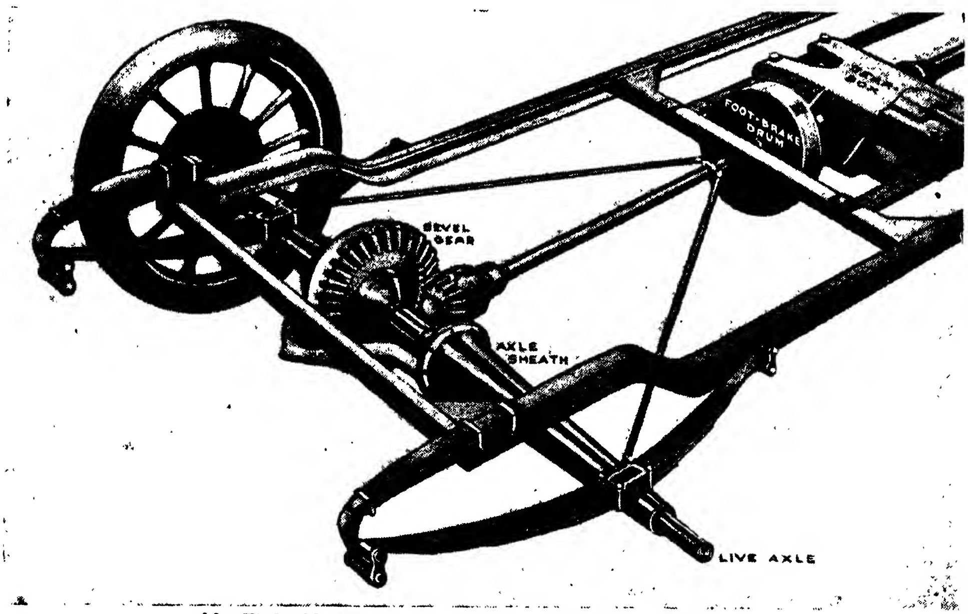
12. WHEN THE CLUTCH IS IN



13. WHEN THE CLUTCH IS OUT

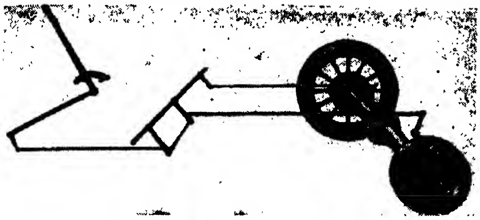
12–13. The clutch on the shaft of the motor-car is a device fitting into the fly-wheel by means of which the main driving shaft can be connected with the crank-shaft driven by the piston-rods of the engine. The fly-wheel is mounted on that shaft, and turns with it. The clutch fits tightly into the fly-wheel, but is mounted upon a shaft which runs through it into the gear-box and then terminates in a cogged wheel

As the clutch spins with the fly-wheel it causes the cog-wheel in the gear-box to revolve. This cog-wheel is enmeshed with a cog-wheel opposite, fixed upon a shaft, called the secondary or counter shaft, which runs across the gear-box, parallel to the main shaft. With the engine running and the car at rest, there are always wheels revolving in the gear-box, but the shaft which drives the road-wheels is stationary, because it is not yet coupled to the engine-shaft. To set the car in motion we must make the main shaft rotate. To do so we press the pedal forward and release the clutch, which is held in the fly-wheel by the force of a powerful spring. It at once begins to spin more slowly upon its shaft, and so does the cog-wheel in the gear-box fixed to that shaft. The cog-wheel on the secondary shaft opposite keeps time, and so, though the engine is running at its former pace, the speed in the gear-box is reduced, and we are now able to move the change-speed lever and cause a second wheel on the secondary shaft to engage with one on the main shaft. That done, we gently let in the clutch, and pass the power of the engine, through the crank-shaft and the fly-wheel and clutch to the meshed gears. The engine is now coupled to the road-wheels, but indirectly—through the cog-wheel on the clutch-shaft and the first wheel on the secondary shaft. This shaft now turns the cog-wheel which is engaged with the wheel on the main shaft opposite (see number 17), and so the main shaft is in turn caused to rotate. The main shaft runs under the body of the car to the rear axle, and ends in a bevelled pinion, which works in with two larger bevel-wheels. And so the revolving of the main shaft makes the road-wheels turn. The clutch is worked in a similar way in changing from first speed to second speed and second speed to top speed.



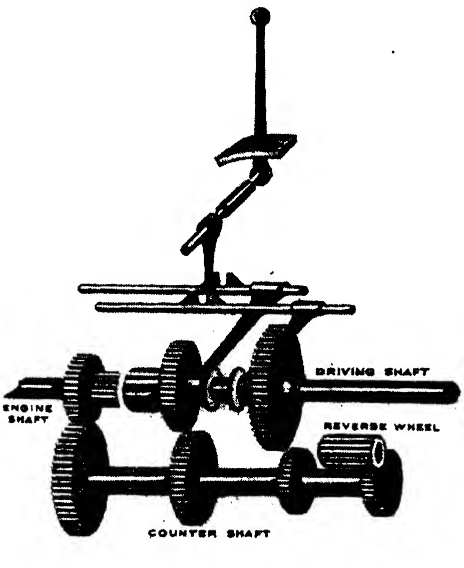
14. THE GREAT DRIVING-WHEEL OF THE MOTOR-CAR

14. The back axle is more complicated than it looks. The real axle is hidden inside the immovable steel sleeves in which it revolves. The axle is in two halves, united at the centre in what we call the differential case. The front axle is fixed, and its wheels revolve upon it, but the main shaft makes the rear axle turn round, and its wheels are fixed to it. The wheels cannot go round unless the axle turns with them; and it does turn, in the great strong sleeves, which are packed with grease and oil. The reason that this rear axle is in two parts is because one wheel travels faster than the other when the car is turning a corner. Small pinions enmeshed with the two big bevels revolve when one wheel turns faster than its fellow, and give the compensation necessary. When the foot brake works, the clutch is taken out, the brake grips the drum on the main shaft, checks its spin, and so slows down the road-wheels which it drives.



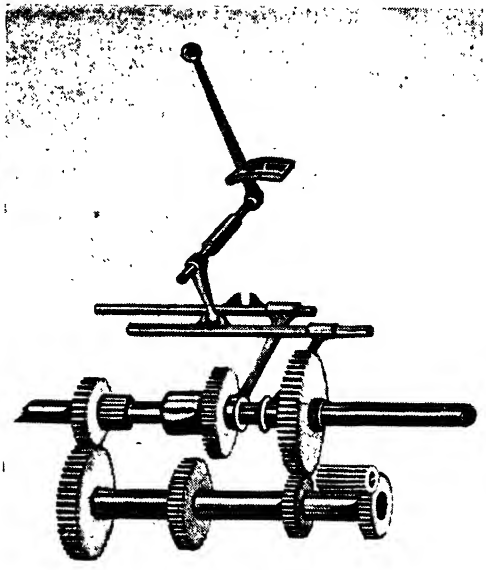
15. THE BACK WHEEL BRAKE

15. This little diagram shows how the hand expansion brake works on the back wheels. Fixed round the inner hubs of the wheels are two drums. The pulling of the handle works a series of levers, at the end of which are two cams. The turning of each cam makes two semicircular bands grip the inside of each drum and slow down the wheel.



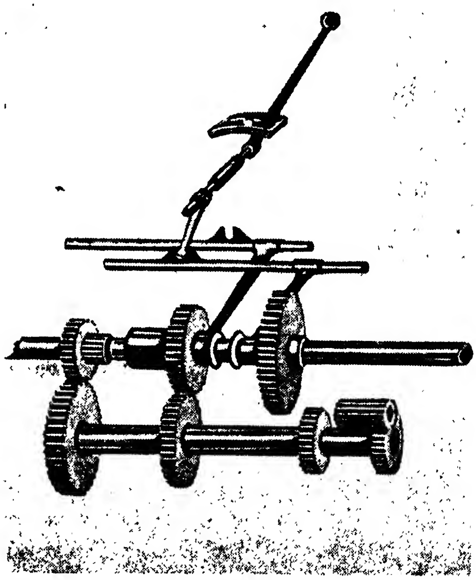
16. THE GEARS AT NEUTRAL

16—20. Wonderful as the gearing-box is, its principle is quite simple. If a large cog-wheel, turning slowly, fits into a smaller cog-wheel, the smaller wheel will go round much faster; if the large wheel is four times as big as the small one, the small one will go four times as fast. Gearing is based on the principle of engaging cog-wheels of different sizes to obtain different speeds. We may say that the power of the engine is fixed, but what is wanted is that the application of it should be elastic. Its burden varies considerably. In climbing hills the pull is much more severe than on the level, and the engine would come to a standstill



17. FIRST OR SLOWEST SPEED

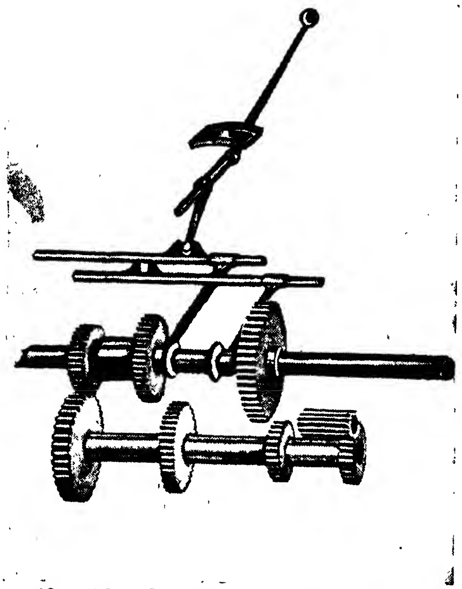
unless we could gear down from top speed and direct drive to a lower gear. The engine itself runs faster than ever now, but it turns a combination of gears which are more easily driven, though the speed of the car slows greatly. In a word, we have to return to the indirect drive as when we started. There are five positions possible



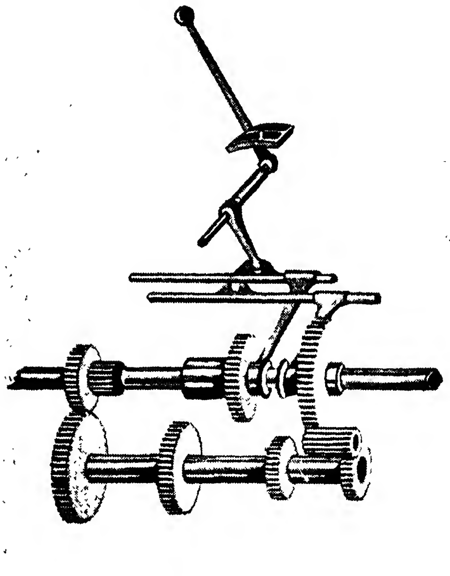
18. SECOND OR MIDDLE SPEED

for the gear-lever—it can stand at neutral, as it does when the car is still, or it can stand at top speed, lowest speed, or middle speed, or at reverse. Pictures 16 to 20 show the cog-wheels inside the gear-box. In 16 the gears are in neutral position; notice that the lever is in the middle, or in the "gate," as the driver says. Though the engine may be going, and even though the clutch may be in, the car cannot go, because none of these cog-wheels is engaged. Notice the driving-shaft in 16. There is a big wheel on the right, a smaller wheel on the left, and on the left of the smaller wheel is a cap grooved inside. This grooved cap is really the end of the driving-

to the big cog-wheel below it—on what is called the "counter-shaft"—and then to the middle-sized wheel on the counter-shaft, which carries the power on to a wheel of the same size on the driving-shaft. Thus the middle wheel goes round very fast, the big wheel much more slowly, and the middle-sized wheel goes at middle speed. It must be clearly understood that the driving-shaft is never engaged with the engine-shaft except on the direct drive, as in picture 19. The very small cog-wheel attached to the end of the counter-shaft is for reversing; it turns the driving-shaft in the opposite direction to the engine-shaft. It will help you to understand these gear-wheels if you



19. THIRD OR TOP SPEED—DIRECT DRIVE



20. REVERSE FOR THE CAR

shaft, and the toothed core attached to the smaller wheel beyond it belongs to the shaft linked to the crank-shaft by the clutch. When the gears are neutral, as in 16, the power of the engine-shaft is not transmitted to the power of the driving-shaft in any way. Compare picture 16 now with picture 19, in which we see that the grooved cap on the end of the driving-shaft is gripping the toothed core on the end of the engine-shaft. In 19 the power of the engine-shaft is carried direct to the driving-shaft, and the various cog-wheels below are revolving simply because they must, and not to any purpose.

In picture 18 the power is transmitted through the little wheel of the engine-shaft

will get clearly into your mind the fact that the engine-shaft and driving-shaft work direct only when gripped as in picture 19, but at all other times they are independent, and that at these other times the power is transmitted from the engine-shaft to the driving-shaft by means of one or other of the wheels below. In order to make this clearer, a distinct break has been made between the engine-shaft and the driving-shaft in picture 16, although in reality the shaft runs a little beyond, as shown in the subsequent pictures. It must be borne in mind, also, that these diagrams are exaggerated for the sake of clearness, the cog-wheels being closer together in the gear-box.

HOW LACE IS MADE

THE DARK TALE OF THE CURTAIN THAT HANGS IN THE LIGHT

The lace curtain that hangs at the window, beautifying the cottage and adorning the mansion, is so like many millions of similar curtains as to form one of the most commonplace things in our lives. But there is a volume of history behind the curtain at the window which fills us with mingled gladness and shame as we remember it.

Woven into the pattern of the curtain is the story of far voyages of discovery, expeditions of ruthless conquest, of enslaving of men and women and children, of wars and rebellions, and a frightful chapter of wrongs. And after that comes a chapter of stirring history of brave endeavour and ingenuity, of the making of machines, of the rising of furious men against them, of dire poverty in our own land and in the East when the machine made its way, and, finally, of the success of the machine, and the growth of a vast industry to take the place of a little group of handworkers.

The cradle of the lace curtain, as of the whole cotton industry, was the little ship on which Columbus sailed into the West to find the East. He knew all about the cotton plant, for he had seen the cotton which the industrious Moors had long been carrying to Spain from the far East Indies, and when he found cotton growing wild on the first island at which he landed, Columbus thought he must have come to the western part of India. Of course, the islands were the group lying on the eastern coast of Central America, but he called them the West Indies, and so they are called today, though they should really be called the East Americas, half a world away from the place he thought he had reached. Portugal discovered soon afterwards the sea route to India, and her traders were able to bring to Europe the cotton fabrics made in that land of ancient civilisation. Spain tried to compete against the rival nation by planting cotton in the newly-found America; but Spain could always conquer a country more easily than she could develop it, and it remained for a little band of Englishmen slowly to win both West and East for England. In the words of Carlyle, it was as if the better part of mankind said, "Shall half the world be England's for industrial purposes . . . or shall it be Spain's for arrogant-torpid, sham-devotional purposes, contrary to every law?" England won America, and zealously grew cotton; she won India, and one of the foremost entries in the charter first given to the East India Company to trade with India was the right to deal in Indian muslins and other cotton goods. Then, at last, when England was able to command a cotton supply for herself, she started her own great cotton manufacturing trade, and no longer bought the made-up goods of India. The day of the Nottingham lace curtain was rapidly drawing near, but had not yet arrived, for a hundred years ago the proudest prince could not have been supplied with curtains made by a machine. Before this came about a tragic chapter of history was to be written.

African negroes were stolen from their homes, and carried as slaves to the Southern States of America to grow cotton. In the course of a century English and colonial ships carried three million slaves from Africa to America. Cotton was the chief cause of slavery in America. The time came when the better feeling of Americans, after they had cast off the yoke of British rule, began to think that slavery was a disgrace, and it happened that this feeling was helped by the fact that slaves were not very profitable. A slave could clean only about five pounds of cotton fibre in a day, and for such a small gain it was not worth while to stain a nation's honour. Thirteen of the best States made slavery illegal; only the Southern States held out.

Then an extraordinary thing happened. Eli Whitney invented his wonderful cotton-gin—a machine for cleaning the raw cotton from the impurities

PREPARING THE DESIGN FOR THE LACE MACHINE

THE DRAUGHTSMAN AT WORK PREPARING THE DRAUGHT FROM THE DESIGN FOR THE FIGURE SHEET

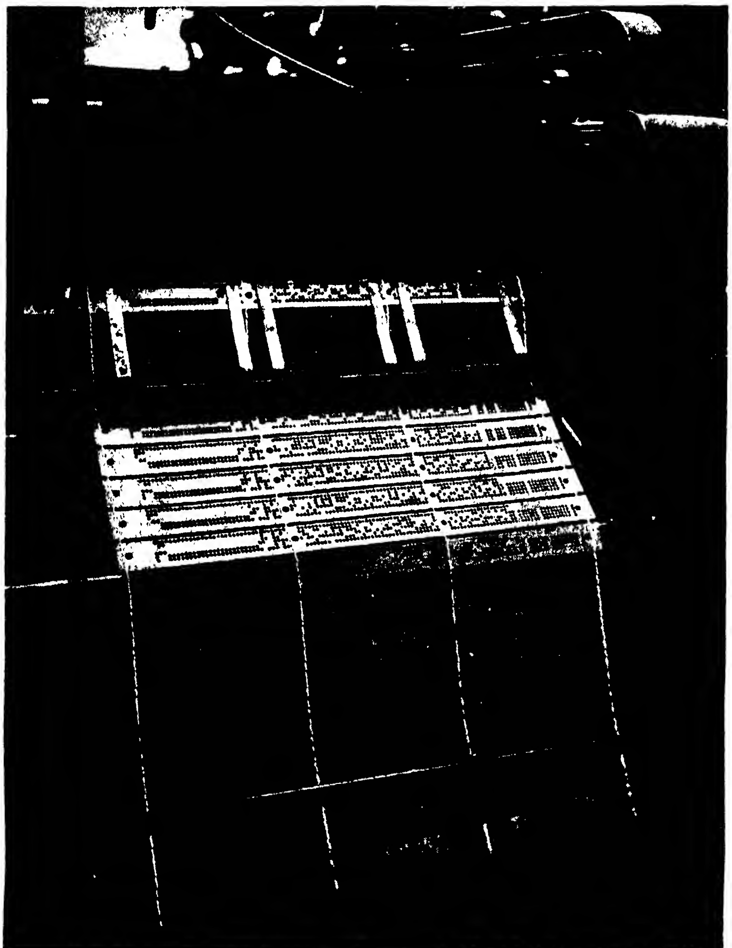
PUNCHING HOLES IN LONG CARDS, CORRESPONDING TO THE FIGURES ON THE FIGURE SHEET, WHICH CORRESPOND TO THE PATTERN OF THE LACE

LACING THE WONDERFUL CARDS TOGETHER

LACING THE CARDS INTO A SORT OF CHAIN, WHICH WORKS ROUND A PERFORATED CYLINDER ON THE JACQUARD, GUIDING THE THREAD TO MAKE THE PATTERN

Through the holes in these cards, steel "droppers" rise and fall, so working the steel bars stretching from end to end of the machine, through which the long beams are threaded.

of seed and husk and dirt. That machine could with ease clean a thousand pounds of cotton a day, so that a man or woman engaged in growing cotton became worth a small fortune. This great invention thus unhappily riveted slavery more firmly than ever upon the Southern States, and it was not until the greatest and most terrible war known to the modern world, the American Civil War, had been fought that the South restored to her slaves the liberty it had stolen from them.



THE WONDERFUL CARDS, PUNCHED WITH HOLES REPRESENTING THE PATTERN, WHICH WORK ROUND AT THE END OF THE MACHINE AND, BY CAUSING THE RISE AND FALL OF LITTLE RODS, GUIDE THE THREADS OF THE PATTERN

By this time a vast trade in cotton manufacture had been built up in England. All sorts of cotton goods were being made in Lancashire, but Paisley, on the one hand, and Nottingham, on the other, started trades of their own, and have never lost them. Paisley to this day makes cotton thread for half the world; Nottingham makes the curtains.

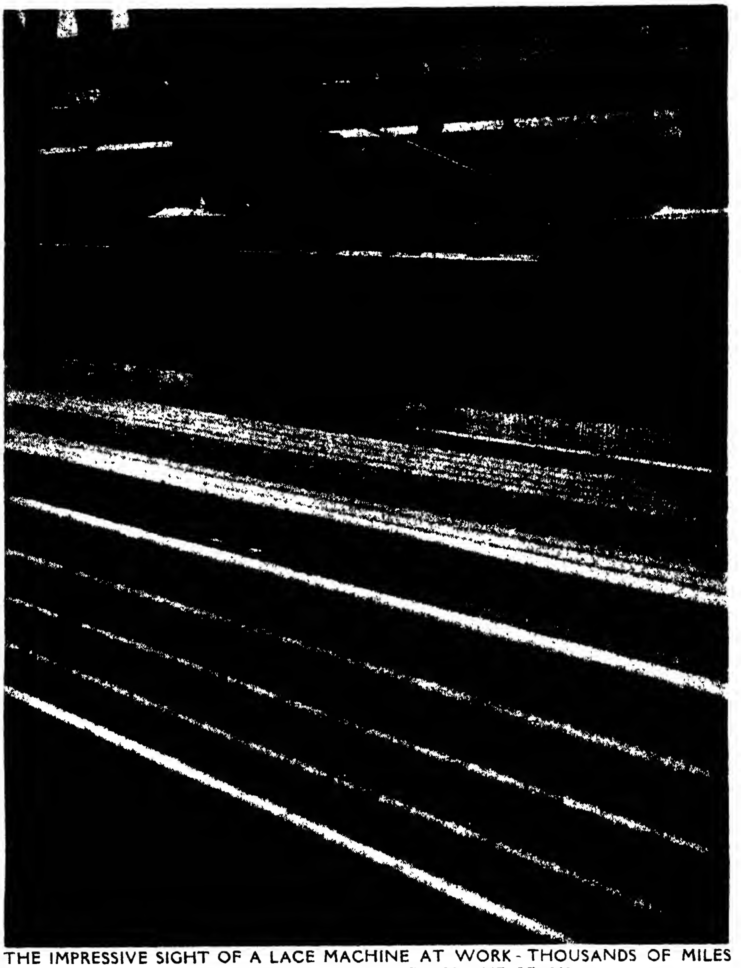
Many clever men worked in secret to build up the trade by making machines for spinning cotton threads from the raw material. James Hargreaves, a man who could neither read nor write, made the first spinning jenny, which enabled men to spin cotton in great quantities without using their hands. The men of that age, however, had a deadly hatred of machinery. They did not realise that machinery was providing them with an enormous supply of material for their labour; they only thought that the effect was to rob them of the work of their hands. And so they gathered together from three or four small Lancashire towns, marched like an army to the house of Hargreaves at Blackburn, smashed his machines and his furniture, and destroyed the factory at which he worked. The poor inventor fled in dismay to Nottingham, where he found a friendly, bright-witted carpenter ready to help him; and these two, the man who could not read or write, and the humble carpenter, started the first little cotton factory in Nottingham. Richard Arkwright followed a little later with his famous spinning machine, and he, too, was so persecuted that he had to flee to Nottingham, where one of the principal streets of the city today is named after him. Then an ingenious clergyman named Cartwright invented the first power loom, and the mob

burned down the factory at Doncaster in which he had set up his machines.

Evidently Nottingham treated its inventors better than other towns, or there would have been a very unimportant Nottingham today. Out of the machines that had gone before, a clever man named John Heathcoat produced one to make lace by machinery. It was at once successful, and Heathcoat set up a factory at Loughborough, a little town in Leicestershire; but the machinery-breakers followed him there and broke up all his plant, and Loughborough, which might have been a great town today, remains a comparatively small place.

Although Heathcoat's machine was the most complicated known up to that time, it was made still more complicated by John Levers, of Nottingham, who built a famous machine which is still the foundation of lacemaking. All that has been done since has been merely gradual improvement upon what Levers accomplished. Of course, there are many machines for work that Levers never knew, but for the most important part of lacemaking—the finer laces—the Levers machine, with its improvements, still stands.

It would be impossible to describe the machine in small space, but in effect it is this. From the skein the cotton is wound on to wooden bobbins, from which it is run on to beams—of which there may be 200—or on to brass bobbins, of which there may be 5000. By marvellous mechanical arrangements, strips of card, punched with round holes in accordance with the design, cause little steel rods, or "droppers," to rise and fall, so bringing into play the various items of mechanism which control the run of the thread. The threads from the long beams pass through fine steel bars, which move from right to left, being worked by the little rods. The threads from the brass bobbins are worked from front to back, so that the two threads are being constantly crossed and recrossed in a way determined by the holes in the cards.



THE IMPRESSIVE SIGHT OF A LACE MACHINE AT WORK - THOUSANDS OF MILES OF COTTON UNWINDING FROM THE BEAMS

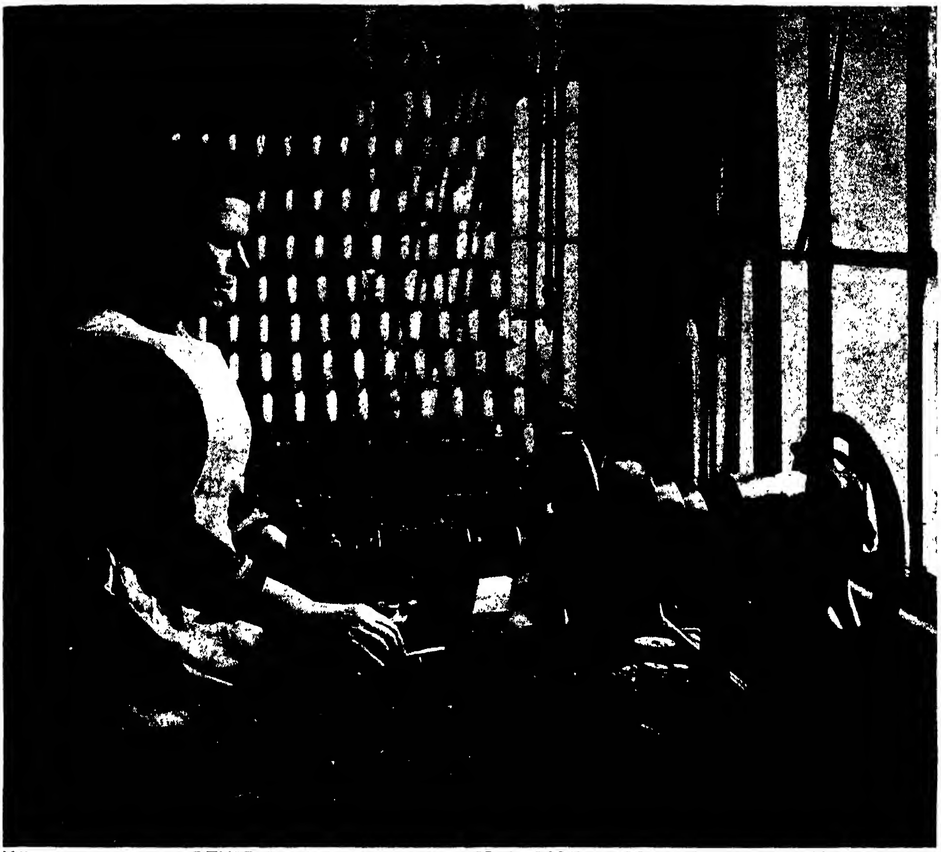
That, in brief, is the way in which lace is made, though curtains, generally of coarser lace, have slightly different machinery of their own. The finishing is largely done by hand, and there are many processes; but nothing is so wonderful as the making of the lace itself, and the lace machine is often said to be the most wonderful thing that men have made with steel.

WINDING THE THREAD THAT MAKES THE LACE

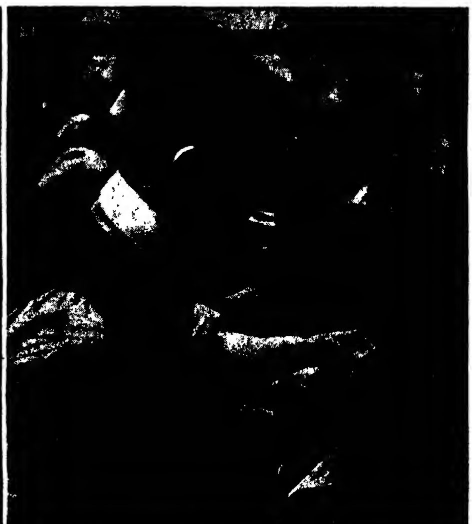
WINDING THE THREAD FROM THE SKEIN ON TO THE WOODEN BOBBINS, FROM WHICH IT IS WOUND ROUND THE LONG BEAMS

WINDING THE THREAD FROM THE WOODEN BOBBINS ON TO THE LONG BEAMS

THE BRASS BOBBINS WITH MILES OF THREAD

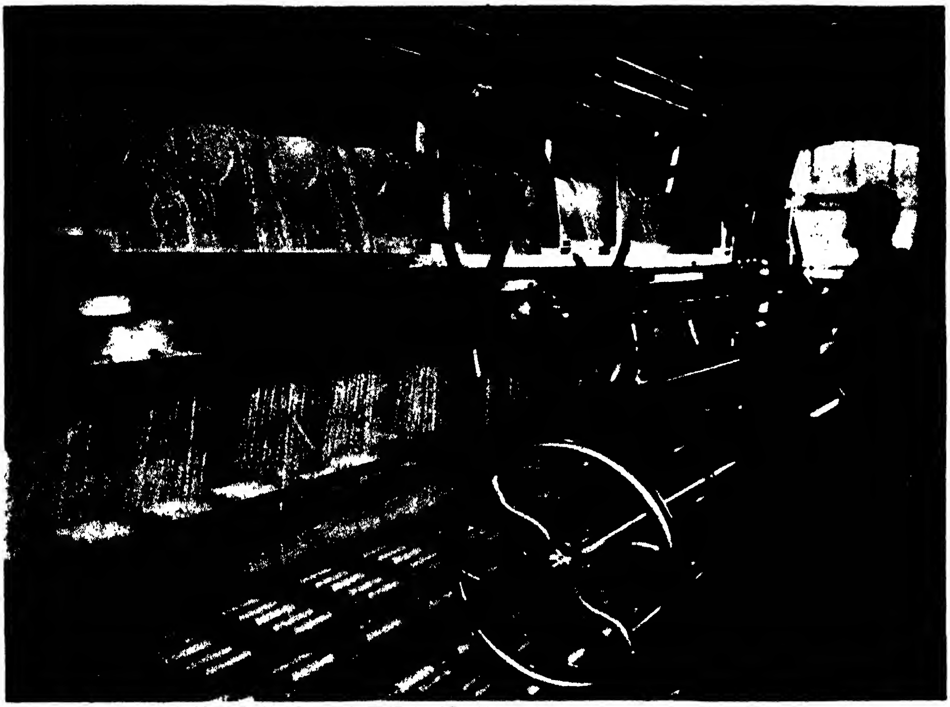


WINDING 80 YARDS OF THREAD ON TO EACH OF 120 BRASS BOBBINS ABOUT ONE-35th OF AN INCH WIDE

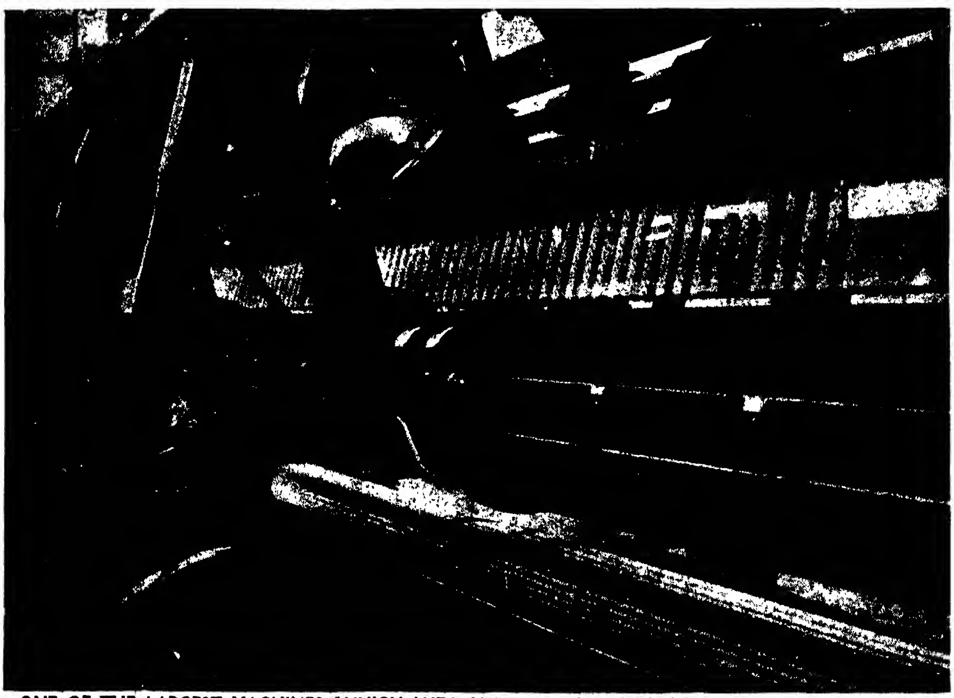


THE MARVELLOUS BRASS BOBBIN WHICH GIVES THE LACE ITS FOUNDATION, SHOWING THE FINE SPRING WHICH HOLDS THE BOBBIN IN THE CARRIAGE AND STEADIES THE THREAD WHEN WORKING

THE TWO LACEMAKERS—MAN AND MACHINE



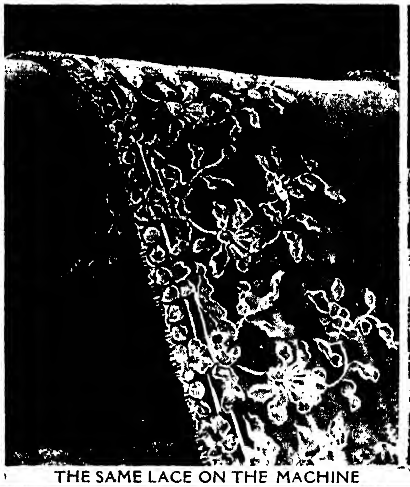
A MACHINE MAKING THE LACE SHOWN ON THE OPPOSITE PAGE



ONE OF THE LARGEST MACHINES, WHICH WILL MAKE 1000 NARROW STRIPS OF LACE AT ONE TIME

A LACE MACHINE THAT SEEMS TO UNDERSTAND

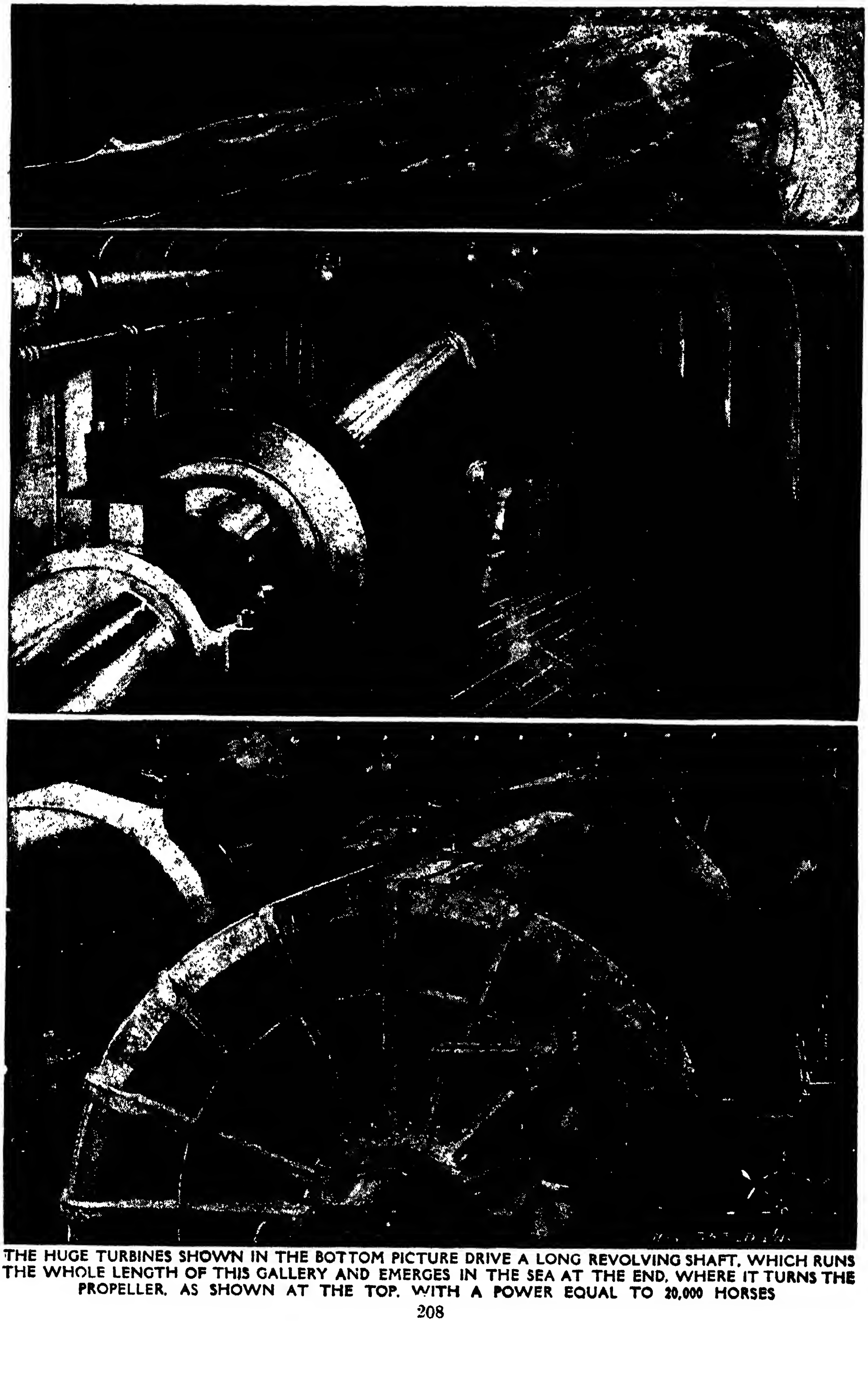

THE PATTERN SHEET


THE SAME LACE ON THE MACHINE


READY FOR A LADY


THE MARVELLOUS MACHINE BY WHICH A GIRL, TRACING A PATTERN ON PAPER AS IN A PANTOGRAPH, GUIDES THE THREAD SO AS TO WEAVE 20 YARDS AT ONCE, WORKING 150 NEEDLES

THE SHAFT THAT MAKES THE PROPELLER GO



THE HUGE TURBINES SHOWN IN THE BOTTOM PICTURE DRIVE A LONG REVOLVING SHAFT, WHICH RUNS THE WHOLE LENGTH OF THIS GALLERY AND EMERGES IN THE SEA AT THE END, WHERE IT TURNS THE PROPELLER, AS SHOWN AT THE TOP, WITH A POWER EQUAL TO 20,000 HORSES

HOW A SHIP IS MADE

THE COMING-UP OF THE OCEAN LINER FROM THE LITTLE BOAT OF LONG AGO

SOMEBODY has been saying that the steamboats plying on the canals in Venice will wash away the banks on which the city stands, and perhaps even yet the rather ugly steamers which ply among the graceful gondolas may have to go. But they will hardly go because they wash away the banks; it is just a hundred years too late to talk like that. A little over a century ago people were saying exactly the same thing about steam navigation in Scotland—not about many steamers, but about one, the only steamer then in the world.

It was quite a small steamer, so small that there was no thought of it ever going out to sea. It was made to haul barges on the Forth and Clyde Canal, in Scotland, and on the first day of its public trial, a day in March of the year 1802, it snorted gallantly along the canal, dragging two barges nearly twenty miles in six hours. A schoolboy can walk as far in the same time. But it was the first voyage ever made in Great Britain by a steamboat, and it was wonderful, as all first feats are. And then, when it was over, and the victory of the steamboat seemed won, the owners of the Forth and Clyde Canal declared that the vessel must not be used, as it would wash away the banks of their canal! So far as Great Britain was concerned, steam navigation seemed at an end, and the maker of the boat was almost broken-hearted. His name was William Symington, and he was one of those humble geniuses who have done so much for the world in the face of discouragement and hardship.

But he was not actually the first to make a steamboat. The idea of causing steam to drive an engine which should drive a paddle-wheel and propel a ship had been in men's minds ever since the properties of steam became known. Paddles, too, were old; the Romans had used them in their galleys, driving them by hand. The great thing was to get mechanical power to make the paddle-wheels turn in the water. As early as 1618 there was a suggestion for a steamboat in England, but the first attempt to put the idea into form was probably that of Denis Papin, a splendid Frenchman, who, driven from France by religious persecution, found a home in England, and in 1707, upon going to Germany, made a little steamboat and packed it up to be sent to England.

It happened that some suspicious boatmen heard what the model was supposed to do, and, fearing that it might ruin their trade, they destroyed it—just as in other days men in England broke up the machinery invented to do the work of their hands. Steamboats were destined to increase the trade of the sailor enormously, and machines were destined to increase industry beyond all dreams, yet sailors and workmen broke up all the machinery they could reach. A quarter of a century after Papin's misfortune, a clever Englishman, Jonathan Hulls, of Campden, in Gloucestershire, built a small steamboat, which had a paddle-wheel at the back, driven by a poor little steam-engine. He launched the interesting little stranger on the River Avon, but it was a failure. It is a strange thing that the name of the inventor was afterward remembered only through a cruel rhyme of the time:

> Jonathan Hull, with his paper skull,
> Tried hard to make a machine
> That should go against wind and tide;
> But he, like an ass, couldn't bring it to pass,
> So at last was ashamed to be seen.

We come then on to 1788, when Patrick Miller, a retired Edinburgh banker, was experimenting with a boat on a little lake in his grounds at Dalswinton, Dumfriesshire. The boat was driven by hand-worked paddles, but the labour was so hard that men could not continue at it. He was therefore introduced to William Symington, who, having been engaged to look after the machinery at a colliery, had made a steam-carriage in his spare time.

He took his model to Edinburgh and showed it to a number of learned men, but could not carry out his scheme, because there were no roads in Scotland fit for a steam-carriage to run upon. The absence of highways, therefore, deprived Scotland of a steam motor-car, but this same cause gave her the steamship. Miller commissioned Symington to build him a little steamship, which was really two boats joined together side by side, with the engine in one boat, the boiler in the other, and the paddle-wheel working between the two.

HOW ROBERT BURNS SAW THE FIRST VOYAGE OF THE FIRST REAL STEAMSHIP

There was a fine gathering to see the first voyage of this little vessel on the lake on October 14, 1788. Robert Burns was there, and the future Lord Brougham, and others of note. Although the engine was small, it drove the boat about the lake at five miles an hour, and encouraged Symington to make another, which went at seven miles an hour. But poor Miller had spent too much money on the work, which brought him almost to bankruptcy, and he died poor and miserable, leaving Symington without a friend and without money. Happily, Lord Dundas, hearing of what he had done, enabled him to build a much larger vessel, which was called the Charlotte Dundas, after the nobleman's little girl. This, the first real steam-vessel of power, tugged two barges weighing 70 tons each along the canal, and caused the owners to fear that the banks would be washed away. The Charlotte Dundas was run ashore, and remained there to fall slowly to pieces ; and that ended poor Symington's career as a shipbuilder. He died a poor, disappointed man. His first engine, long kept in Miller's house as a sort of curio, had many strange adventures, and is now to be seen in South Kensington Museum.

HOW THE WIND CARRIED THE ENGINE OF A STEAMSHIP ACROSS THE SEA IN A BOX

Yet Symington, poor and disappointed, had achieved a revolution. He had taught the world that the steam-engine could drive a ship, and all the other steamships that followed were only developments of his. The great Olympic of today is the child of the little boat which was to wash away the banks of the canal. The immediate result was the building of a successful steamer in America by Robert Fulton, who was on the Charlotte Dundas when she sailed on her trial trip. He himself had tried to build a steamer, but the bottom of his ship fell out, and let his engine slip into the water—just as the engines of the Titanic are said to have fallen out before the ship went down.

Hearing of the success of Symington, Fulton came to England, took the idea of a steamship back to America, and perfected it there. But it was an English engine that drove his ship, built at Birmingham by Boulton and Watt and carried over to America in a box. It is odd to remember that the engine which was to revolutionise life at sea was carried across the Atlantic by the wind. Fulton's ship was launched in 1807, and as she steamed along at night the noise of her machinery and the sparks from her funnel so terrified the crews of other ships that they shrank beneath their decks or let their vessels run ashore, while others "prostrated themselves and begged Providence to protect them from the approach of the horrible monster which was marching on the waves and lighting its path by fire."

But the first really successful steamship in Great Britain came three years after Fulton's, and was the unaided invention of Henry Bell, a Linlithgow man. He had worked for years at the idea, and had profited by the experiences of poor Symington. He had met Fulton, too, and had frankly told the skilful American all his plans. These plans Bell laid before the Admiralty two or three times.

HOW SCIENTISTS REFUSED TO BELIEVE THAT SHIPS COULD BE DRIVEN BY STEAM

It is curious that Nelson, before going out to his last great fight and victory—Trafalgar—went over Bell's scheme and heartily commended it, though Napoleon had scoffed at the same idea when Fulton laid it before him in Paris. Nelson obviously had more imagination in this than Napoleon.

But scientific opinion was still against both Bell and Nelson. Sir Joseph Banks, one of the greatest scientists of that time, who did great things for England, sniffed and poohed at Bell's ideas. "It is a very pretty plan," he said, "a *very* pretty plan, but there is just one point overlooked—that the steam-engine requires a firm basis on which to work." How could any man put fires and furnaces and boilers in wooden ships, when a storm would toss the vessel about, and the fire would be thrown all over the ship, so that the furnace must be put out at the very time it was most needed.

The brave heart of Henry Bell was not daunted by these rebuffs. He went to work on his own account, built a litt e vessel called the Comet, fitted her with an engine of three-horse power, and then, on August 5, 1812, issued the following historic document.

STEAM PASSAGE BOAT, THE COMET,

Between Glasgow, Greenock, and Helensburgh.

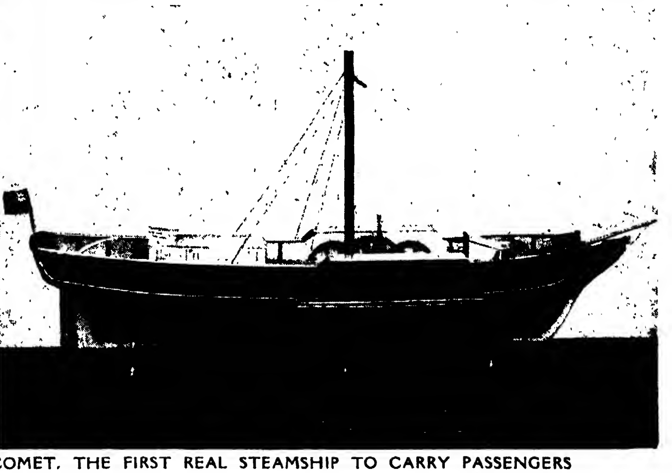
FOR PASSENGERS ONLY.

The subscriber having, at much expense, fitted up a handsome vessel to ply upon the River Clyde, between Glasgow and Greenock, to sail by the power of the wind, air, and steam, he intends that the vessel shall leave the Broomielaw on Tuesdays, Thursdays, and Saturdays, about midday, or at such hour thereafter as may answer from the state of the tide; and to leave Greenock on Mondays, Wednesdays, and Fridays, in the morning, to suit the tide. The elegance, comfort, safety, and speed of this vessel require only to be proved to meet the approbation of the public, and the proprietor is determined to do everything in his power to merit public encouragement. The terms are, for the present, fixed at four shillings for the best cabin and three shillings the second; but beyond these rates nothing to be allowed to servants, or any other person employed about the vessel.

but as she was small she could not carry much coal, and depended largely on sails.

It was the problem of coal which brought the prophets of failure to the front again. in 1838 a learned Dr. Larner lectured at the Royal Institution, and "proved" that it would never be possible for a steamship to cross the Atlantic by steam alone, because she could not carry enough coal. Well, ships somehow did once cross, and have been crossing ever since. They became multiplied, and the effect proved serious in an unexpected way. Our ships were of wood, as they had been since man first sailed the seas.

Now, in Britain forests are few and wood is scarce, and long before shipbuilding became a really great industry the country began to feel the need of material for building ships. A Government official, in 1841, showed that a wooden warship of that time used up timber which had taken eighty



HENRY BELL AND HIS COMET, THE FIRST REAL STEAMSHIP TO CARRY PASSENGERS

years to grow on seventy acres of land. All the royal forests in the kingdom could not supply the timber for one wooden battleship a year. To build the ships used in English commerce, the timber of eight hundred thousand acres would be needed every year.

It was imperative, therefore, that a new material should be found. Iron was proposed, and a terrible outcry the suggestion caused. "You might as well build ships of stone," said the critics. But the critics were wrong, for ships of iron were built. The younger Brunel built a splendid iron ship, called the Great Britain, and sent her steaming across the Atlantic in 1845. Even today people who live far from the sea can hardly believe that our ships are built of iron and steel, and it is only a dozen years since a member of Parliament asked if

The little Comet was a great success in all but profit. There was much opposition from boatmen and coach-owners, and Bell, though he ran his little marvel for eight years before she was wrecked, lost all his money, and was rewarded in the end by a very small pension.

But Henry Bell did a great deal more than run this steamboat on the Clyde. From the first he avoided the mistake of Symington, who sought to keep to the canal; he went out into open water, bravely sailing to all parts of England, Scotland, and Ireland. He was the father of steam navigation in its practical form in Europe, and, once he had shown what could be done, steamships began to rise in all directions. In 1814 London had her first steamer on the Thames, the Marjory. In 1819 a little steamer, the Savannah, crossed the Atlantic to America;

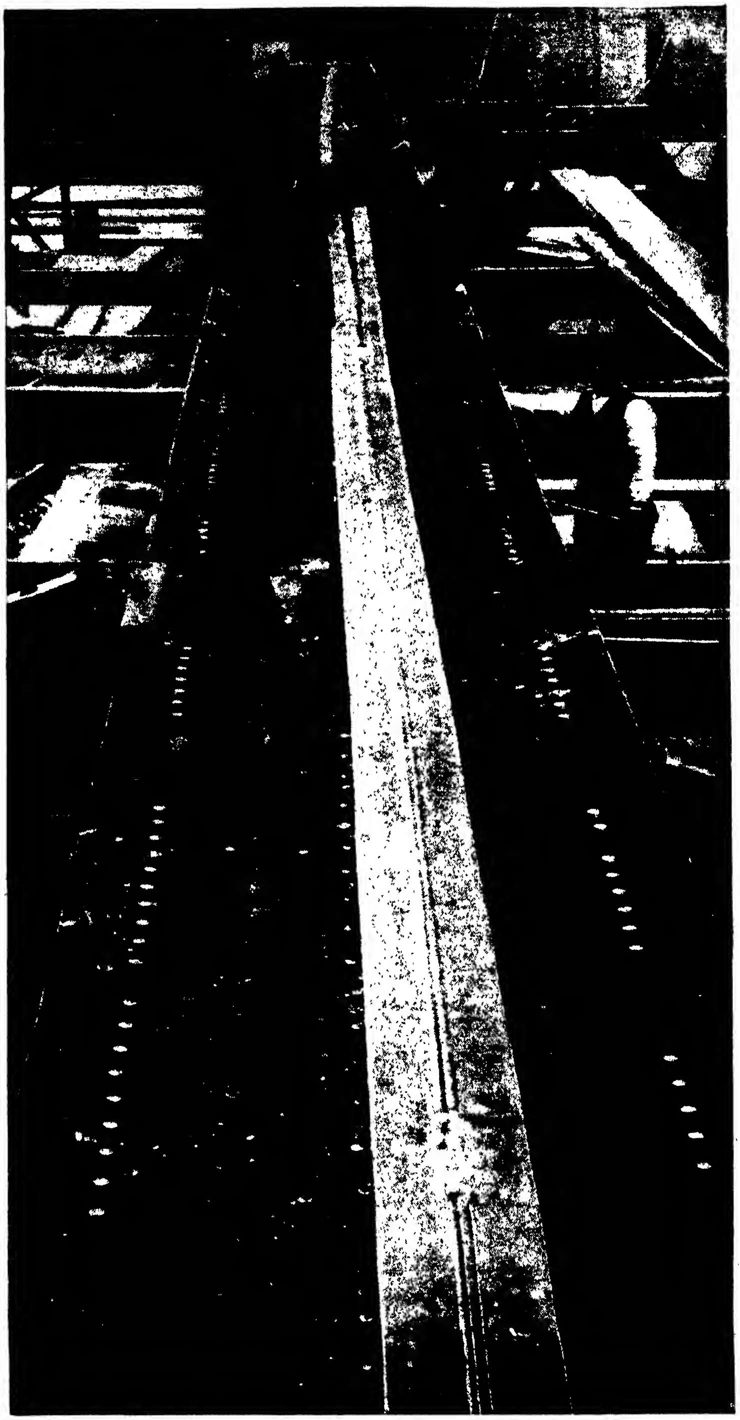
LAYING THE DOUBLE KEEL-PLATE THAT RUNS FROM END TO END OF A SHIP
The great cross girders at the end are seen in position on page 64; the upright plate in centre bears the T-piece shown opposite.

battleships were still made of wood. If a pin sinks in the water, how is it that a steel ship, weighing thousands of tons, can float like a feather? The secret was discovered 2000 years ago by Archimedes, when, as he stepped into a full bath, the water overflowed. Now, a body in water displaces exactly its own weight of water. If we throw into water a solid mass of iron weighing a ton, the iron will sink; but if we beat out the iron into an enormous hollow box, it will not sink. It still displaces its own weight of water, but its weight is distributed over a big surface.

It is as easy for a vessel of fifty thousand tons to float, if it is spread over a great surface, as for an eggshell. If we throw into the water a new egg, it will sink; but if we pour its contents into a larger shell, which lies upon a greater space of water, it will float like a cork. The whole weight of a vessel of fifty thousand tons does not press upon one area, but is distributed over a great space, and if the ship is not overweighted so as to push aside too great a volume of water from beneath, it will float, whether it be of iron or wood. Nowadays big steamers and little are built of iron or steel, and their triumph dates back

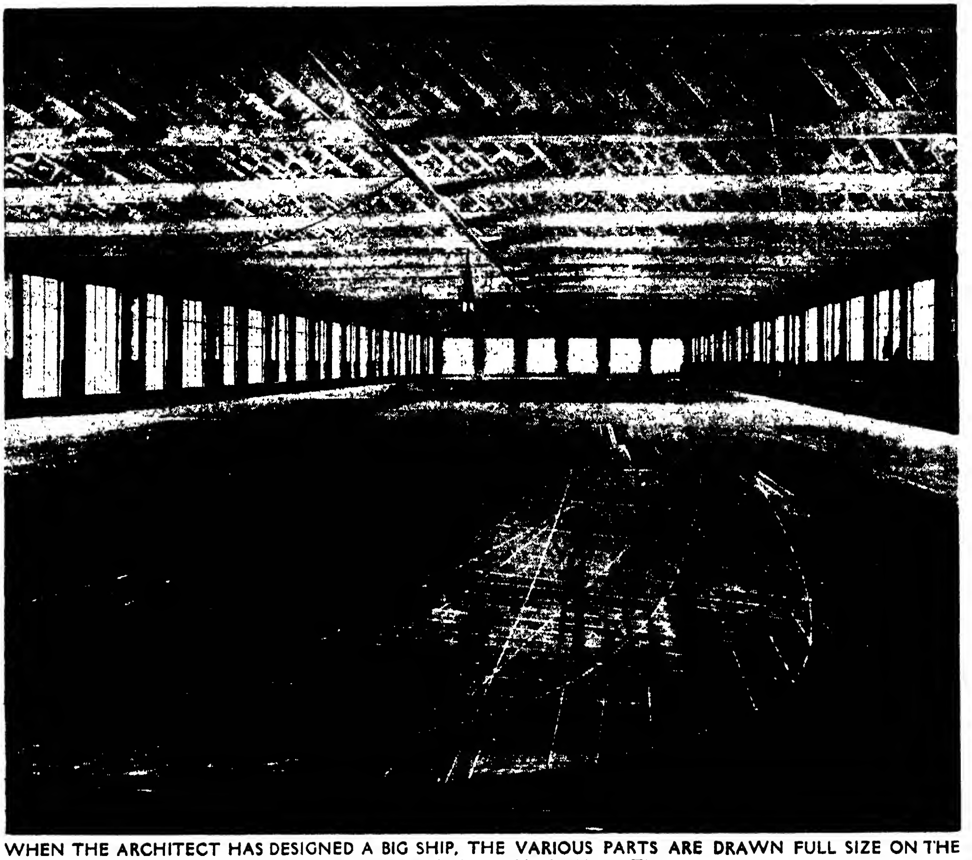
to the sailing of the Great Britain in 1845.

But it was not then her success so much as her failure that converted the ship-builders. After she had been running for some time, she was accidently driven aground, and lay on the rocks for eleven months before she was got off. Ship-builders went to see her as she lay stranded, and went again when she was removed into dock. They found that, in spite of the accident and the long exposure to the waves, she was practically uninjured. That converted them. The success of the metal ship really dates from that wreck. The whole story of the steamship has been one of daring effort by a few men without power or influence, and of stupid opposition on the part of those who were supposed to know best. Science has, of course, now come to the aid of the ship-builder, and everything that concerns a ship is supposed to be worked out in theory before a beam is laid. But theory is not always right. The theory of the Titanic was that it was unsinkable, but she lies two miles deep in the North Atlantic Ocean — a terrible warning to us to remember that, with all our knowledge and our mastery of the sea, there are still things beyond the power of man to do and beyond the wit of man to understand.



FIXING THE GREAT STEEL CENTRE-PIECE FROM END TO END OF A SHIP
The long T-piece in the centre is laid on the upright keel-plate seen on the opposite page

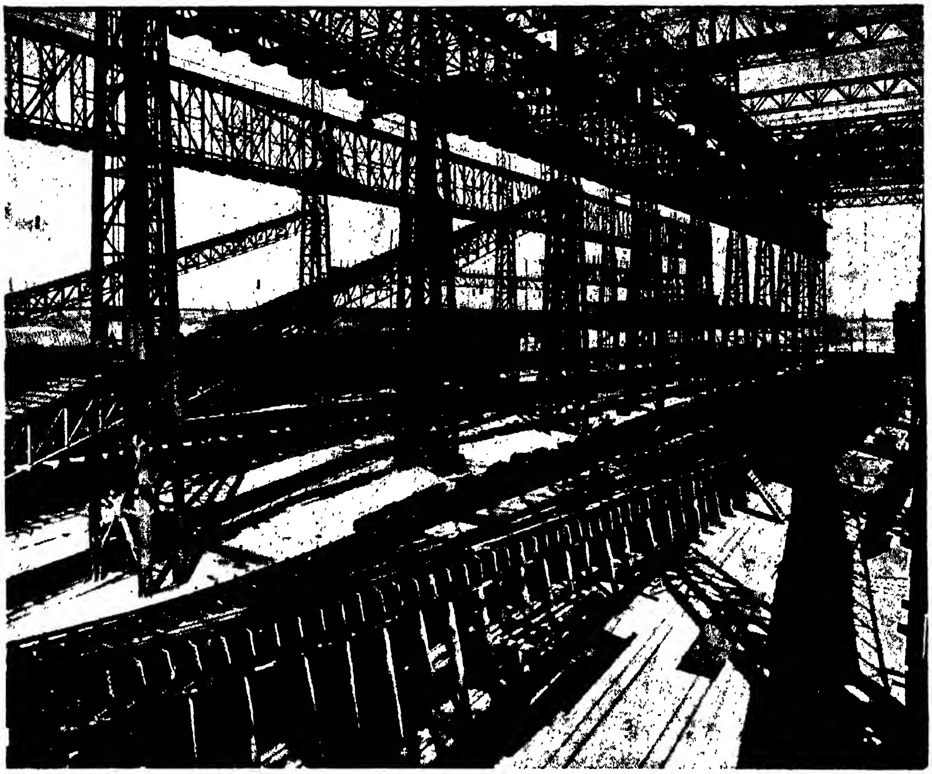
DRAWING THE FIRST PICTURES OF A BIG SHIP



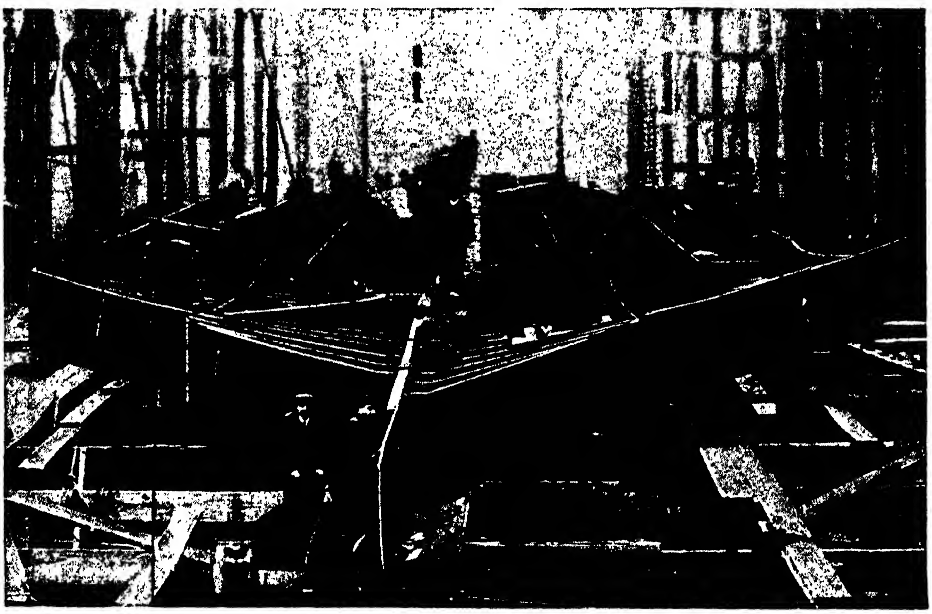
WHEN THE ARCHITECT HAS DESIGNED A BIG SHIP, THE VARIOUS PARTS ARE DRAWN FULL SIZE ON THE FLOOR OF A HUGE ROOM SUCH AS THIS

WOODEN MODELS ARE MADE FROM THE DRAWINGS OF THE SHIP, AND FROM THESE THE IRON AND STEEL PARTS ARE CAST

THE DOUBLE FLOORS OF A FLOATING PALACE

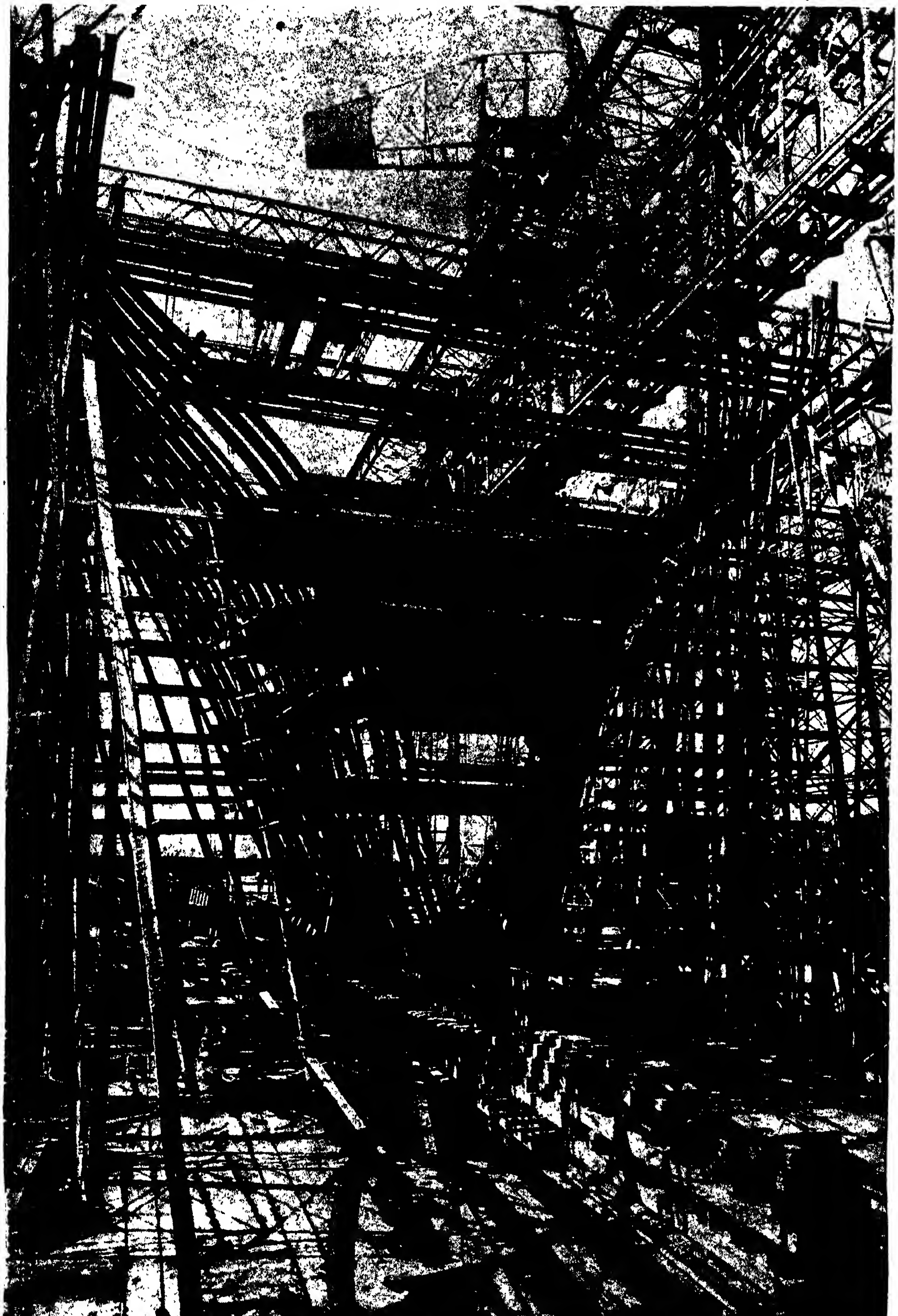


THE IMMENSE DOUBLE FLOOR OF THE OLYMPIC BEING BUILT UP ROUND THE KEEL



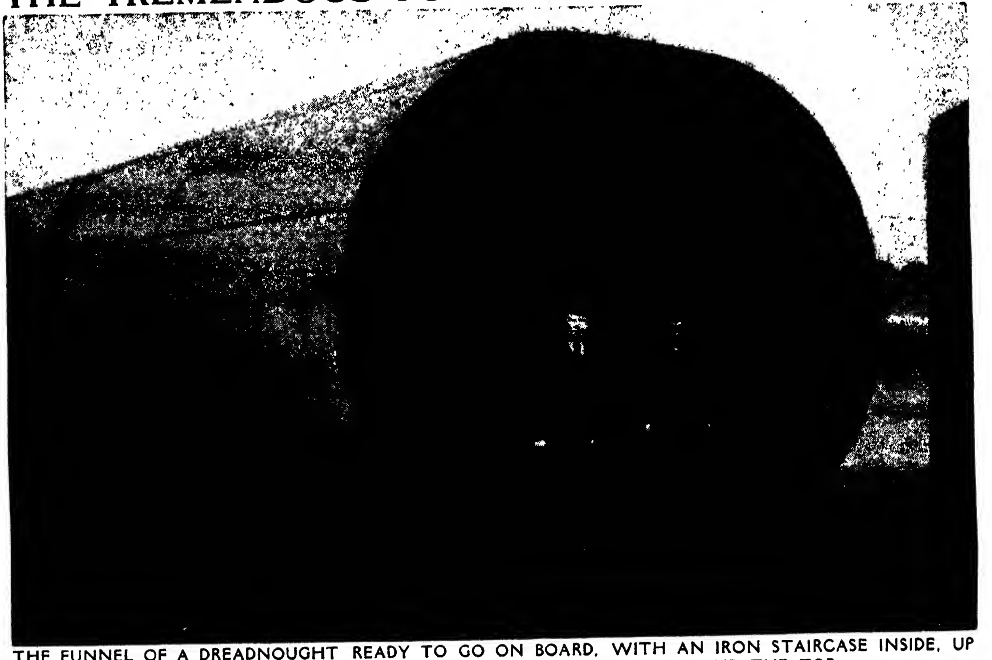
LAYING THE DOUBLE FLOOR OF ONE OF THE GREATEST SHIPS AT SEA

THE STEEL SKELETON OF AN OCEAN GREYHOUND



THE FRAMEWORK AND DECK-GIRDERS OF ONE END OF THE OLYMPIC, SISTER SHIP OF THE TITANIC

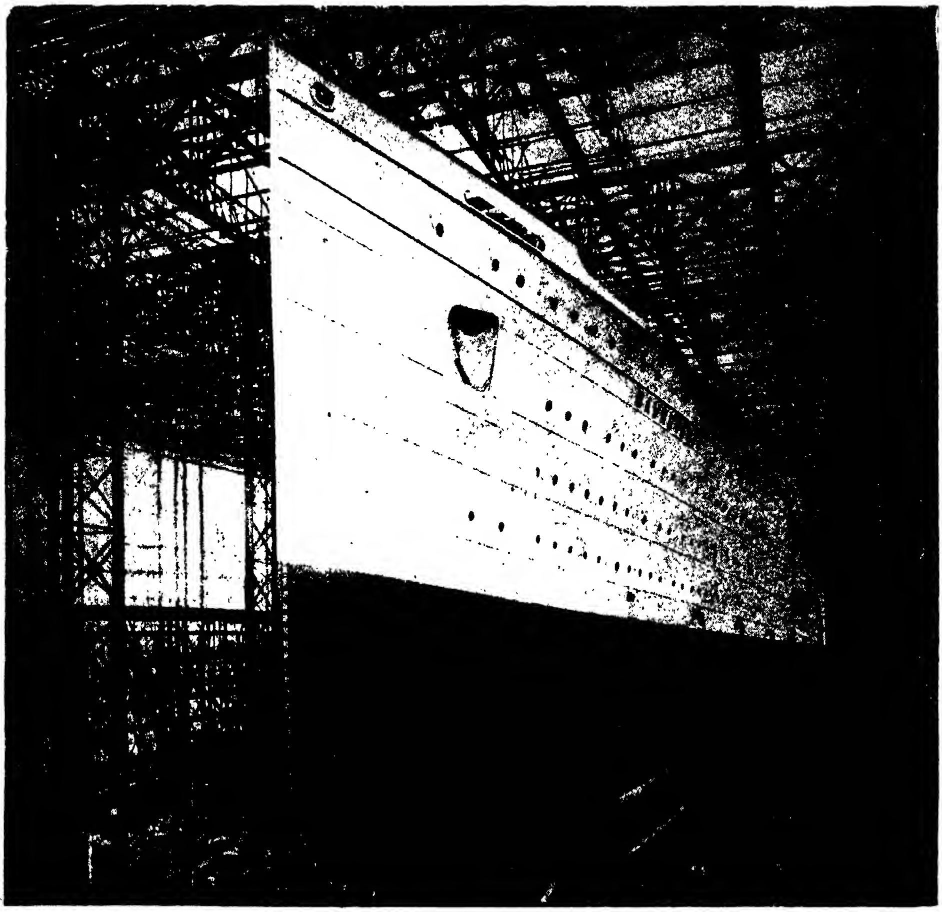
THE TREMENDOUS FUNNELS OF A GREAT SHIP



THE FUNNEL OF A DREADNOUGHT READY TO GO ON BOARD, WITH AN IRON STAIRCASE INSIDE, UP WHICH SEAMEN MAY CLIMB TO A PLATFORM RUNNING ROUND THE TOP

THE MIGHTY FUNNEL OF A CUNARD LINER, EVEN BIGGER THAN A WARSHIP'S, WITH ROOM ENOUGH FOR TRAMCARS TO PASS THROUGH

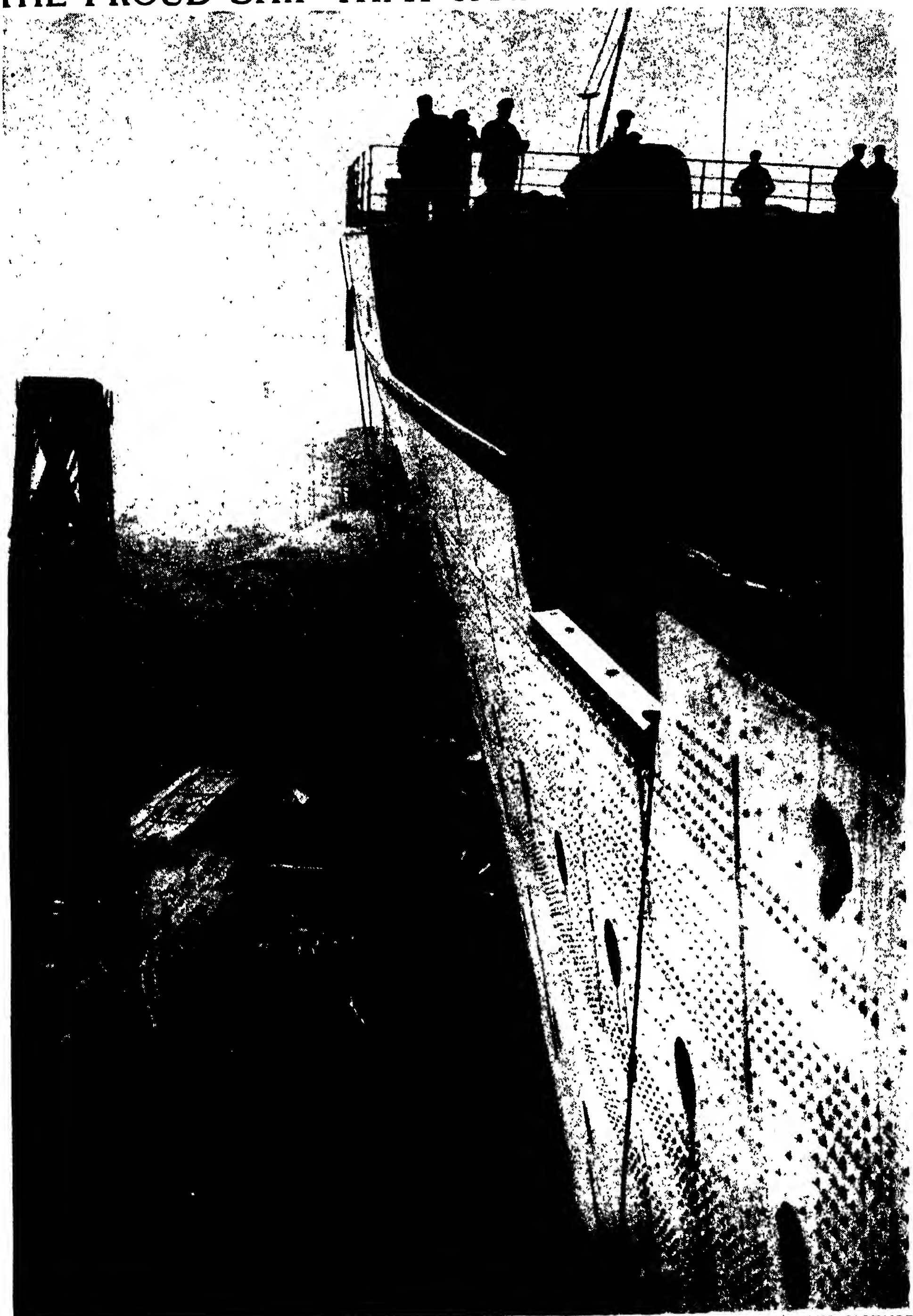
IN AND OUT OF THE SHIPBUILDING SHED



INSIDE THE SHED, WITH THE MAURETANIA NEARLY FINISHED AND READY FOR LAUNCHING

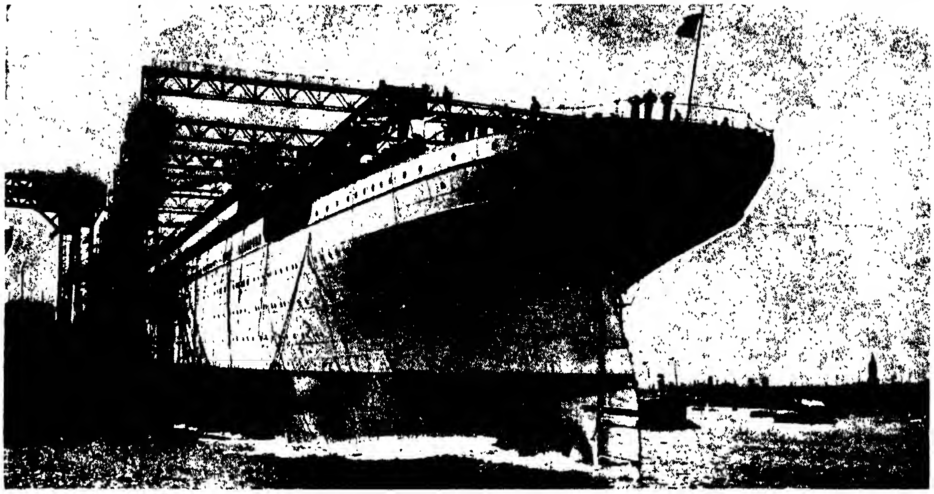
THE OUTSIDE OF THE GREAT SHED IN WHICH AN ATLANTIC LINER IS BUILT

THE PROUD SHIP THAT HOLDS ITS HEAD HIGH

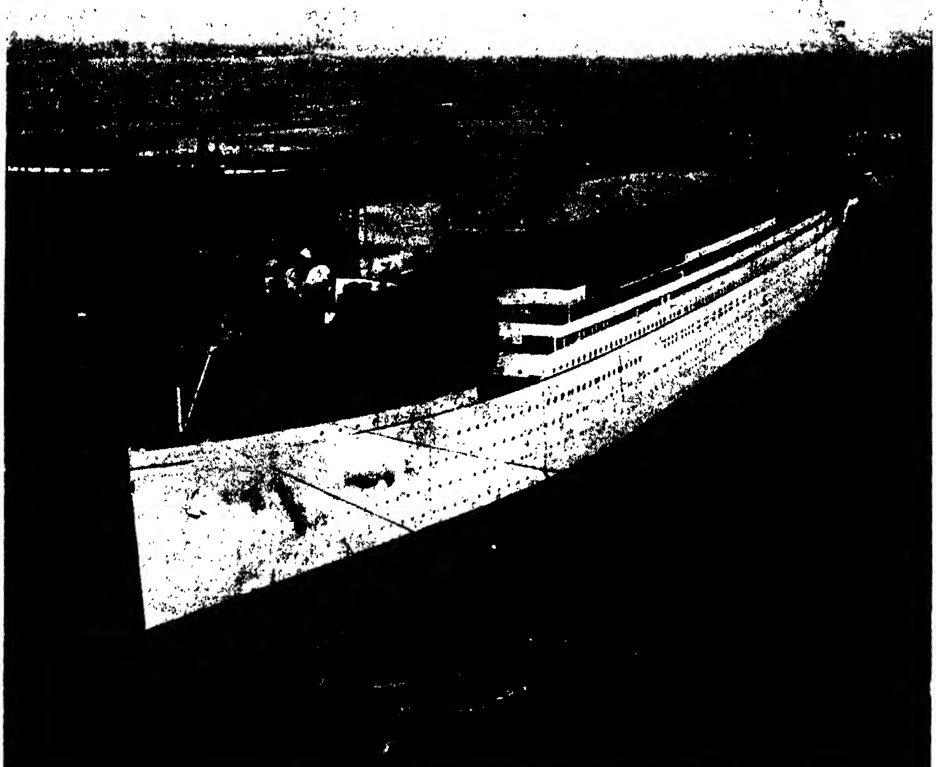


THE IMMENSE HEIGHT OF THE MODERN FLOATING PALACES IS CLEARLY REALISED FROM THIS PICTURE OF THE OLYMPIC STANDING IN THE SHIPYARD. FROM THE KEEL OF THE OLYMPIC TO THE TOP OF THE FUNNEL IS 175 FEET, AS HIGH AS A FIFTEEN-STOREY BUILDING

THE GREAT SHIP TAKES THE WATERS



HERE THE OLYMPIC IS SLIDING DOWN INTO THE SEA, OVER THE "WAYS," WHICH HAVE BEEN MADE SLIPPERY WITH HUNDREDS OF POUNDS' WORTH OF GREASE AND SOAP



THE GREAT SHIP REACHES THE SEA, AND IS READY TO RECEIVE HER MACHINERY AND FITTINGS

Many of the photographs in these pages were obtained by the courtesy of Messrs. Harland and Wolff, and of Messrs. Swan, Hunter, and Richardson, shipbuilders.

ALL ABOUT A BALL

WHY IT DOES WHAT IT DOES AND GOES WHERE IT GOES

It is curious how many people look on science as something dry and remote from ordinary life, a subject to be learned from books with experiments carried out by means of strange apparatus in a laboratory.

Such a view is as incorrect as it is old-fashioned. Science touches every one of us everywhere and every day, and the smallest child cannot play a game without carrying out a scientific experiment and illustrating some of those great laws of Nature that govern the universe.

Take, for instance, the oldest of all toys, the ball. A whole world of fascinating science is opened up to us every time we play a game of cricket or football or tennis. Even the ball itself, lying at rest on the ground, is illustrating many important natural laws. Leave the croquet ball or the billiard ball or the cricket ball for a week or a month, it still remains a ball. Why? If you roll up a ball of dough and leave it resting on the table it will soon have flattened out—it absolutely refuses to remain the beautiful sphere that you made it. Or, if you press together a mass of sand to form a ball and leave it, it soon falls apart and becomes once more a mere mass of loose sand.

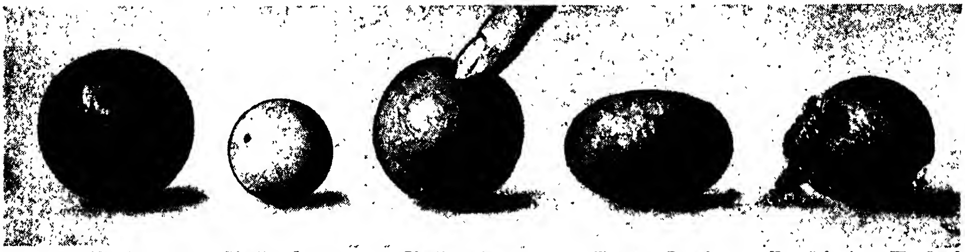
The ball of ivory or rubber or wood, and even the dough, is held together by cohesion, the force that holds together the small particles, or molecules, of a body. When the sand was a solid piece of rock, cohesion held it together, but the forces of the waves overcame the cohesion, and the rock was broken up into fragments. Now, cohesion is a force that acts only when the particles are such a tiny distance apart that it is hardly perceptible, and when pressing the sand together with our hands we can never get the particles sufficiently close to make them cohere. If they hold together for a time when damp, it is really the particles of water that cohere, but cohesion acts weakly in liquids, and so the sand soon falls apart.

The next thing we notice about the cricket or croquet or billiard ball is that it possesses rigidity, which is the property that distinguishes a solid from a liquid. In common language, rigid means stiff or inflexible, but this is not its scientific meaning. Even a jelly possesses a certain rigidity—in other words, it will not flow—and, however soft a material may be, if it has no power of flowing it is a solid. Now, a dough ball flattens out slightly—in other words, it flows a little—and so it is really a liquid, a viscous, or thick and sticky, liquid, but, nevertheless, a liquid. Of course, the dough may be made so stiff that it becomes a solid, and will not flatten of itself. In that case it is a plastic solid, which can be moulded to any shape. It would also be spoken of as ductile, or capable of being drawn or pressed out. It is the cohesion and the rigidity that keep a ball round.

We often speak of a ball as hard or soft, but hardness is only a relative term. If we take a billiard ball, a cricket ball, and a child's indiarubber ball, the cricket ball is hard as compared with the rubber ball, but soft as compared with the billiard ball.

Some balls possess the property of elasticity—that is, they are able to resume their original form after being compressed—but the degree of elasticity depends upon the substance of which the ball is made. A wooden ball has very little elasticity; a hard blow will permanently dent its surface. Ivory, on the other hand, possesses a great deal of elasticity. When two billiard balls meet on the table in play, although our eye does not work quickly enough to see it, *they are flattened, and instantly resume their original shape.* This has been proved by dropping an ivory billiard ball on

a polished marble slab smeared with oil. A circular impression of oil is made on the ball, and, as this increases in size the greater the height from

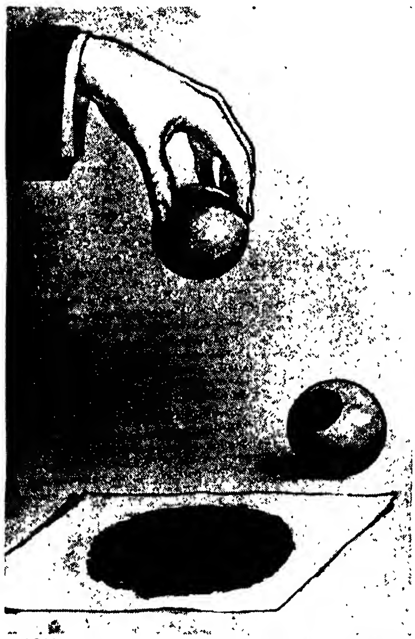


Rigid—Wood   Elastic—Ivory   Plastic—Clay   Viscous—Dough   Non-Cohesive—Wet Sand

THE FIVE KINDS OF BALLS—RIGID, ELASTIC, PLASTIC, VISCOUS, NON-COHESIVE

which the ball is dropped, it is clear that the ball gets more flattened the greater the distance it falls. The separation of the balls after they collide on the table is also a proof of their elasticity—they flatten upon contact and then suddenly spring back to their original shape, driving each other apart.

Indiarubber is very elastic, but the bouncing of the ball is due, not to the elasticity of the rubber alone, but also to that of the air inside the ball. This, when the ball strikes the ground, is compressed, owing to the flattening of the rubber, but it suddenly expands, owing to its elasticity, and throws the ball up again.



HOW WE CAN SHOW THAT A BILLIARD BALL IS ELASTIC

If an ivory ball be dropped from a height on to a surface smeared with printer's ink it will have a round patch of ink of considerable size on it, showing that it must have been flattened when it fell.

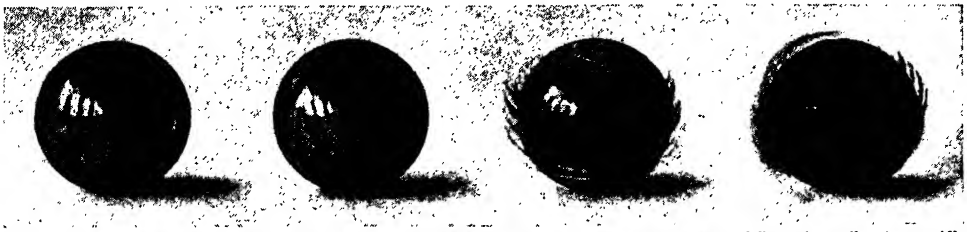
If we were asked to define Newton's First Law of Motion, we might not be able to do so; we might even declare ourselves ignorant that such a law existed. And yet the smallest child who can play with a ball knows the law as well as Newton, for it simply declares that a body at rest, such as a ball lying on the ground, remains at rest unless acted on by an external force. A baby knows that this is so; and if he wants a ball that is resting on the ground he does not call to it to come, or beckon to it—he goes to get it, or calls to somebody to throw it to him.

A ball at rest is an interesting example of a body in neutral equilibrium. Equilibrium means equal balance. In every body there is some one point, called the centre of gravity, at which the whole weight of the body may be said to act. Now, when the body is resting in such a position that the centre of gravity is in the lower part, and an imaginary line dropped perpendicularly from it falls within the base of the body, that body is said to be in stable equilibrium—a slight push will not throw it over into another position. When the centre of gravity is in the upper part of the body as it stands, and a slight push will send it over to a new position, the body is in unstable equilibrium. But when, as in the ball, the centre of gravity is so placed that no alteration of the position of the body can raise or lower the centre of gravity, then the body is said to be in neutral equilibrium. A ball is

the very best example of neutral equilibrium that can be found

So much, then, for the science the ball teaches us when at rest. Now let us bowl a cricket ball along the lawn and see what happens. Newton's First Law of Motion mentions not only that a body at rest will continue motionless unless acted on by an external force, but that a moving body will continue to move forward in a straight line unless stopped by some force outside itself. The cricket ball, therefore, it would seem, should go on bowling along the lawn until stopped by the wall, or by someone catching hold of it; but we know very well that this will not be the case. Even if given a powerful initial motion on a long stretch of level lawn, the ball will gradually slow down and eventually stop, without the intervention of any apparent forces. What are the forces that stop the ball?

Well, first of all there is gravitation, or the pull of the earth. This is constantly trying to drag the ball down towards the centre of the earth, and, naturally, retards its horizontal motion. Then there is the resistance of the atmosphere, which, though unseen, is very real. Its action against the moving ball is the same as when a hurricane blows upon us and makes progress difficult. Then, in the third place, the blades of grass exert a certain amount of resistance, and the ball has to overcome this. Finally, there is the friction, or rubbing, of the ball against the ground. In all these cases a certain amount of the energy we give to the ball in bowling it is used up in overcoming the resistance of gravitation, air, grass, and ground, and so the ball slows down and stops. The friction of the ball running over the ground may seem a very small thing, but, no matter how smooth and level the ground may be, as on a billiard table with its slate bed, the friction would eventually stop the ball, even if no other forces were in play.



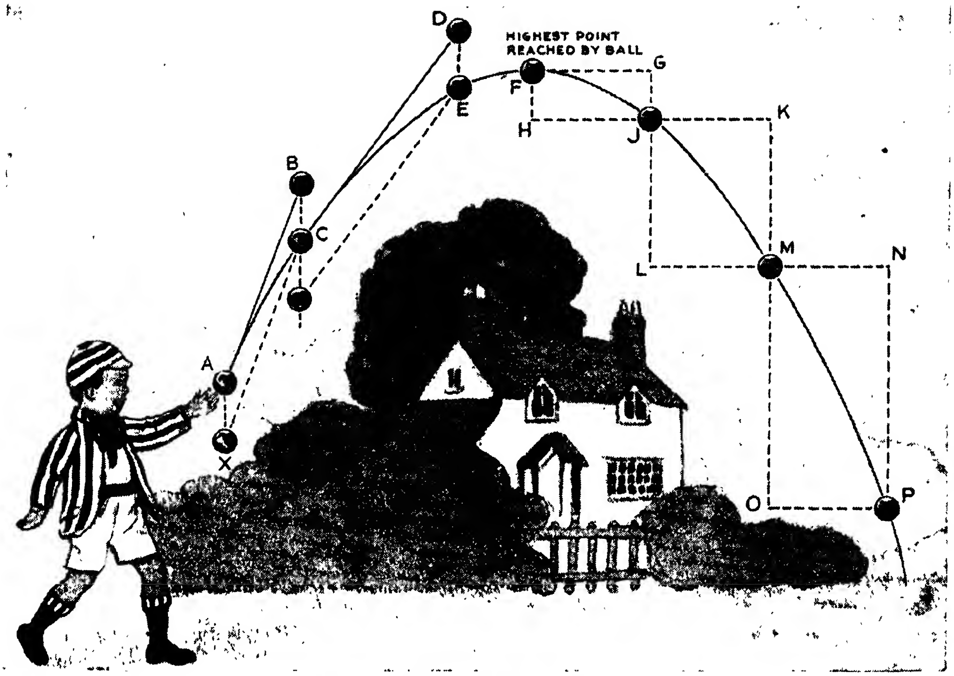
When the ball is at rest we see the actual number of stripes that are on its surface | When the ball is rolling there appear to the observer to be more stripes than there are | When the ball spins slowly stripes appear at the poles and the rest is a neutral colour | When the ball spins rapidly the whole of it is a neutral colour and no stripes are seen

THE WAY OF THE STRIPED BALL AND WHAT THE EYE SEES

Here the ball lies in neutral equilibrium | Here the mallet is in stable equilibrium | Here the mallet is in unstable equilibrium

THE THREE KINDS OF EQUILIBRIUM ON THE CROQUET LAWN

If we watch the ball closely as it moves along, we shall notice that it has two motions. It moves forward and it goes round and round—that is, it revolves on its axis as it moves.



THE WAY OF A BALL THROWN INTO THE AIR

This diagram helps us to understand the explanation given on another page of why a ball thrown into the air always describes a curve called a parabola (slightly modified by the air and gravitation), as illustrated on page 227

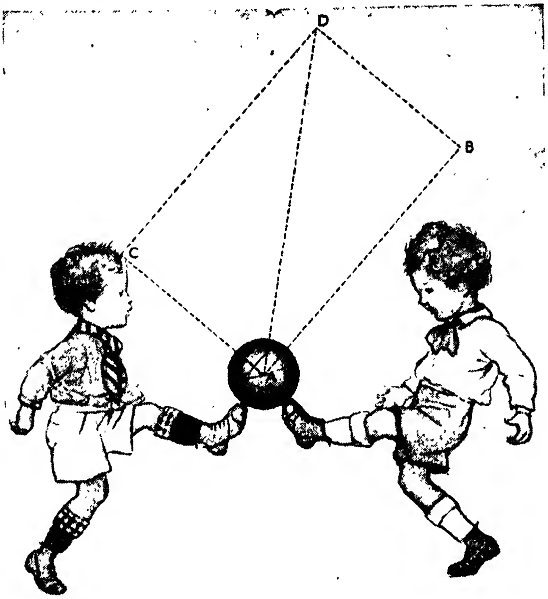
If we try to send the ball along the ground without the rotatory motion, we shall find that it is practically impossible to do so ; it will certainly revolve, and the reason for this is interesting. As the ball moves, the friction tends to retard its motion, but this applies only to that part of the ball actually in contact with the ground ; the upper part of it has no friction, because it is not touching the ground. The upper part, therefore, moves forward more quickly than the lower, but, as it cannot fly forward without the rest of the ball, cohesion holding the whole thing together, the upper part comes down till it touches the ground and friction retards it. But the part that was previously touching the ground is now on top, and, being free from friction, it moves more quickly. It then moves down to the ground, and so, this process being continually repeated, the ball revolves as it goes forward.

THE FORCES THAT STOP A ROLLING BALL

Were it not for counteracting influences, a thrown ball would move for ever. It is stopped by its weight pressing on the earth and causing friction, which rough ground increases, and by the resistance of the blades of grass and the air.

The revolving is particularly noticeable if we use a striped ball, and here we observe something fresh. As the ball revolves, it appears to have a greater number of stripes than when at rest. This is because the stripes are presented in such rapid succession to the eye that the impressions over-

lap—the eye receives fresh impressions before the previous impressions have passed away. Hence the stripes appear multiplied. But we shall notice, if we spin the ball fairly quickly on the ground or on a table, that the stripes disappear and rings are seen at the opposite poles of the ball, while in between there is a uniform colour. Before going into the explanation of this, let us spin the striped ball or a large striped marble very quickly. All the lines and stripes disappear, and the ball is a uniform colour all over. The different parts of the surface are brought so rapidly in succession to the eye that the impressions on the retina become confused and blend into a single colour. On the other hand, when the ball spins less rapidly and rings are seen at the poles, the impressions of the stripes are conveyed to the eye just quickly enough to follow in succession without being confused. At the equator of the ball, however, owing to the greater circumference, the speed at which the surface is moving is much greater than at the poles, and the stripes are confused.



THE BALL KICKED TWICE AT ONCE

One boy's free kick would send the ball from A to C and the other boy's from A to B, but if they both kick together the ball will go to D This diagram and that on the next page help us to understand why.

In the balls we have been speaking of, the centre of gravity has been in the very centre, but when we come to the game of bowls we have balls weighted unevenly inside, so that the centre of gravity is "thrown out." The result is that the ball does not run true; owing to the uneven weight,


THE WAY OF A BOUNCING BALL

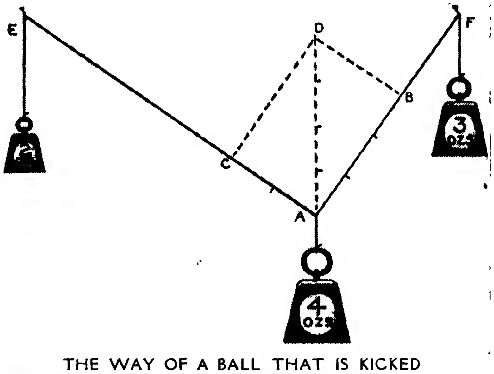
An indiarubber ball bounces high and long if dropped on a hard pavement. This is because of the elasticity of the pavement and the air inside the ball, friction with the ground and resistance of the outside air finally stopping it. But if the same ball is dropped on sand so much of its energy is taken up with moving the loose sand that it hardly bounces at all.

or bias, on one side, the ball takes a curved course, varying according to the way in which it is bowled.

Now let us take a ball and throw it into the air. We shall notice that in its passage from our hand to the ground it always describes a curve. If it were not for the resistance of the air and the fact that the pull of *gravity* is towards the centre of the earth, and not in parallel lines, this curve described by the ball would always be what is called in geometry a *parabola*. The shape of the curve is, however, on account of the causes mentioned, somewhat modified, so that it is not a true parabola. As in bowling, so in throwing, several forces act upon the ball. There is, first of all, the force of projection, communicated by our hand; then there is the resistance of the atmosphere through which the ball passes, which diminishes its velocity without changing its direction; and, finally, there is the force of gravitation pulling it to the earth. No matter how great the force of projection that may be given to a ball, it must always be less than the resistance of the atmosphere and the pull of gravitation, and so, sooner or later, the ball must be brought to the ground.

Now follow the ball from the thrower's hand to the ground. All the time it is going up or down the atmosphere is retarding its progress, and the force of gravitation is pulling it to the earth. Were it not for gravitation, the ball, on leaving the thrower, would go up in a straight line, as from A to B in the diagram. But the pull of the earth, acting all the time, would take it to X. It therefore follows a curved course, and arrives at C. At C, and, in fact, at every point in its upward progress, according to Newton's First Law of Motion, it tends to go on in a straight line, but again, instead of reaching D, it is pulled by gravitation to E. Thus all the time the ball is following a curved course, and this continues until the velocity has been so retarded by the air, and the ball so pulled down by the earth's attraction, that it no longer has sufficient projecting force to carry it higher. It then reaches its highest point, and begins to descend. But here a new principle comes into play.

If the forces of projection and gravitation which act upon the ball produced uniform motion, the ball would follow a straight line in descending from its highest point to the ground. But the velocity of a falling body is continually increasing, and this is the reason the ball describes a curve in coming to the earth. The matter is made clear in the diagram. But we must first of all remember that men of science have found by experiment that a body descending from a height falls 16 feet in the first second, three times sixteen in the second, five times sixteen in the third, and so on. Now, at F the ball is at its highest point. The projecting force would take it in a straight line to G, but gravitation would draw it to H. The result is that the ball follows a curved diagonal and reaches J. Here the projecting force would take the ball to K, but gravitation would draw it down three times the distance FH—that is, JL. The ball, therefore, follows a curved diagonal, and reaches M. Here the projecting force would take it to N, and gravitation pull it down to O, five times the distance FH. The ball, therefore, arrives at P. This is continued until it finally alights on the ground, and so the whole course has described a modified parabola—that is, the outline obtained when a cone is cut through parallel with its side.

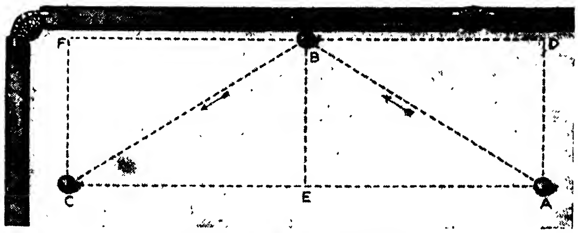


THE WAY OF A BALL THAT IS KICKED

This diagram helps us to understand the experiment described elsewhere to explain the science of a double kick in football.

This tossing of the ball into the air has taught us a very important principle of mechanics, called the parallelogram of forces. The name sounds formidable, but the principle can be easily explained by an experiment. Fix two pegs, E and F, into a vertical board, and over these hang a flexible string with weights attached, as shown in the picture. Now mark off on the left-hand string two inches to represent the force of the two-ounce weight, and on the right-hand string three inches to represent the force of the three-ounce weight. Using CA and AB as sides, draw the parallelogram CABD, and join the diagonal AD. It will be found that AD is four inches long,

and it represents both the direction and the magnitude of the combined forces exerted by the two and three ounce weights. In other or more scientific words, if the two forces acting at a certain point be represented in magnitude and direction by the two adjacent sides of a parallelogram, then their resultant or combined effect is represented both in magnitude and direction by the diagonal of the parallelogram passing through the point.



THE WAY OF A BILLIARD BALL

When a billiard ball strikes the cushion at an angle it goes off in another direction at an equal angle. This diagram shows the course of the ball.

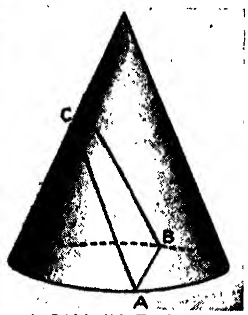
The picture gives an example of a game of football. Two boys rush at a football, A, and kick it at exactly the same moment. One kicks it in the direction B, with a force sufficient to carry it twelve yards; the other kicks it in the direction C, with a force to carry it eight yards. We form the parallelogram ABDC, join up the diagonal AD, and see at once that the ball would go along that line sixteen feet. In exactly the same way we can resolve or split up any one force into the two forces which combine to produce it, and that is what we did in studying the curved course of the ball thrown into the air.

We have already spoken of the elasticity of indiarubber and other balls, and explained why they bounce. But why does a ball stop bouncing? Here what is known as the law of the persistence of power comes in—that is, that nothing is lost or created. When the ball begins to bounce there is a certain amount of power or energy in it. But as the ball moves up and down it forces aside, every moment, millions of particles of air, and the motion it gives to them it loses. A certain amount of the energy which caused the ball to bounce in the first place is communicated to the substance on which it bounces, and when all the force or energy has passed from the ball it comes to rest. If the ball could bounce in a room emptied of air, it would bounce much longer than it does in an ordinary room filled with the atmosphere, and if, in addition, the ball and the ground were perfectly elastic, and the ball never turned so as to rub or set up friction with the ground, it would go on bouncing for ever.

When we bounce a ball on soft sand or on a bed or pillow, it will not bounce very much. This is because its energy is used up in moving the sand or the bed in addition to the air. Then we know how much better a sound indiarubber ball will bounce than one which has a hole in it. This is a proof that the elasticity is not due entirely to the indiarubber; it owes a great deal to the air inside. When there is a hole, if the ball be thrown on the ground, the air is expelled as the rubber gives, and so there is less air inside to return to its original shape after it has been compressed by the impact with the ground.

ELASTIC IVORY BALLS

When two billiard balls collide the parts that meet go flat and then spring out again like indiarubber, though the eye is not quick enough to notice it. It is because they are elastic that they spring apart.



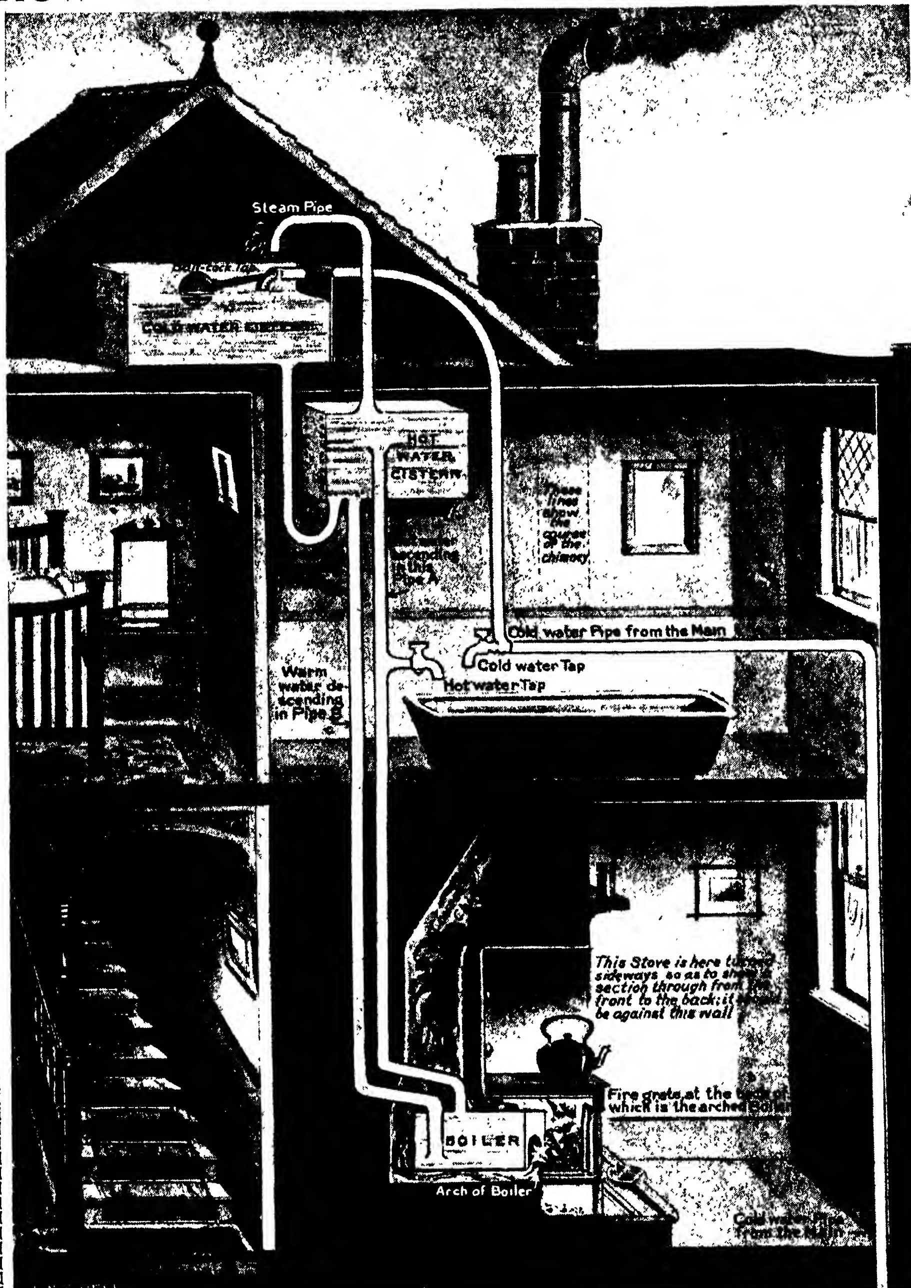
A BALL IN THE AIR

A ball thrown into the air describes a parabola. This is the outline of a figure, ACB, formed by cutting a cone through parallel with its side.

At croquet and other similar games we sometimes see one ball played at another so that the ball struck is driven a long way, while the ball played suddenly stops dead. This is another instance of the results of elasticity. We give to the ball we play a certain velocity, and when this strikes the resting ball it gives to it a velocity equal to its own, and receives in return a blow equal to that which it gave. This blow, acting in the opposite direction, exactly neutralises the motion of the first ball, and causes it suddenly to stop dead.

These are only some of the scientific lessons we may learn from a ball, and other simple toys are equally fruitful in illustrating great natural laws.

HOW HOT WATER GOES THROUGH THE HOUSE



This picture shows how it is that we can get hot water in our bathroom without carrying it upstairs. Cold water comes into our houses from the water-main in the street, and is driven by heavy pressure up into the cistern at the top of the house. Asiphon-shaped pipe from this cistern carries the cold water to the hot-water cistern, and from here the water passes through the pipe B to the boiler in the kitchen stove. The flames of the fire go round and under the boiler, and as the water gets hot, being lighter than cold water, it rises in the pipe A. Soon the hot-water cistern is full of hot water, and cold water, being heavier than hot, cannot rise from the siphon-pipe. Steam escapes through a pipe over the cold-water cistern.

THE GLORY OF THE HEAVENS AND THE EARTH

A SUNSET IN THE 20TH CENTURY. THE MEETING OF FOUR GREAT POWERS OF AIR, EARTH, AND SEA

Why Did Baby's Eyes Change Colour?

In order to understand this fully we should have to know a good deal about the structure of the eye, as well as about colours. But it is enough for our purpose here to say that the colour of the eye depends upon a structure called the *iris*—a kind of curtain made of delicate muscle-fibres which have the power of contracting and relaxing. In the middle of the curtain is a hole, called the pupil of the eye. When the coloured curtain contracts, the pupil enlarges to allow more light to enter, or, when another set of muscle-fibres contract, the pupil narrows to shut out light.

The colour of the curtain depends upon the kind and amount of colouring matter in its cells, and the way this is arranged.

Now, this colouring matter is liable to change as life goes on, and it does change somewhat from birth, appearing less bright as time goes on, and being most dull in old age. We notice the change most in a baby's eyes because it appears more sudden in them, and, having naturally made up our minds that the eye was of one colour to begin with, we notice the change.

Why Does Cold Make Our Hands Blue?

Even in a healthy person we notice that the colour does vary a good deal. The same person is sometimes red in the face as well as blue in the hands, and at other times neither one nor the other. So we might extend this question and ask: Why does the same person change colour in different circumstances?

The answer is that the colour of the skin at any given moment depends upon the kind and amount of blood circulating in the skin at that moment. The blood is the great source of all the colour we notice in people. In the absence of enough blood the face and lips look white or pale, or anæmic, as we say, meaning bloodless. When there is a great rush of bright red blood to the surface, as when a person is taking violent exercise, the skin appears red from the expanding of the smallest arteries; when the skin is exposed to severe cold the opposite happens. The arteries contract and contain less red blood, and the veins expand and contain more of the purplish, impure blood. Further, as the veins on the hands and limbs are nearer to the surface than the arteries, they are more easily seen, and the blue colour of the blood shows through the skin over them, and gives a general bluish tint when the skin is cold. If the hands be now vigorously rubbed, or exercise be taken to stimulate the circulation, the blueness disappears, because the blood assumes its usual course once more.

Why Does a Cat Arch its Back on Meeting a Dog?

It is difficult to be quite sure *why* animals do certain things, unless we know whether they do them in their wild state. If we knew that a wild cat would arch its back on meeting a dog, we might safely presume that it was an instinct on the part of the cat for defending itself. The attitude of the cat with its back arched, and its hair more or less bristling at the same time, might suggest to the dog an object of such ugliness as would terrify it; or one might suppose that the cat, in assuming this attitude, is attempting to get a firm grasp of the earth with its feet, so that, by thus stiffening its muscles, it could scratch its enemy with greater force and defend itself in that way.

But there is another explanation which may be more accurate. When a dog seizes a cat, it does so by the middle of the cat's body, and, by arching its back and bringing the two hind feet as near to the two fore feet as possible, the cat may be trying to protect this part of its body. It is possibly the case that cats learn this from each other and so get into the way of doing it.

Why Cannot Electricity Pass Through Glass?

The shortest answer to this question would be to say that glass is a non-conductor of electricity. But what do we mean by a non-conductor? We mean a substance which will not allow a current of electricity to pass along or through it. This can be tested by an instrument called a galvanometer, which, when we pass an electric current through it, shows on a dial whether there is any current passing or not, and, if there is, how strong that current is. Two wires run from the instrument, and if their ends come together the dial shows the current to be passing. If, instead of this, we make the wires touch something else, we find that the current still passes in some cases, but not in others. Thus,

if we take a coin and put the two wires in contact with it, the current passes. The coin, being metal, acts as a *conductor*. All metals are conductors. But if we take a piece of wood, or porcelain, or glass, and put the wires in contact with this, the instrument shows that no current is passing, and these things, therefore, are *non-conductors* of electricity.

Why Does a Mute Deaden the Sound of a Fiddle?

BEFORE we can understand this entirely, it is necessary to know what *sound* is, and also a little about the construction of a fiddle. By sound we understand something that we can *hear*, and this is really the effect produced by the vibrations of some substance or other. These vibrations of the sounding substance enter the air and are carried to the organs of hearing, which carry them to the brain, and so make us conscious of the sound. No substance can make any sound unless it be put into a trembling, or vibrating, condition, so we may say that sound is the motion of vibration, impressed upon our senses.

A musical sound, like that from a fiddle, is caused by a regular series of exactly similar vibrations, succeeding each other at precisely equal intervals of time. These vibrations consist of those of the strings and also of the wood of the bridge of the fiddle. The little implement known as a "mute" is made of wood, ivory, or brass, and when in position grasps the bridge of the fiddle. By compressing the bridge, the mute makes the vibration of the bridge less free, lessening also the vibration of the strings, so that the sound from them is made softer and altered in quality. The mute interferes with the production of the ordinary full vibrations, and so deadens the sound from the fiddle.

Why Should We not Eat the Skin of a Plum?

THE skin of a plum has nothing in it of much use to us as a food, so that it is not worth eating; and the skins of most fruits consist of chemical substances which we cannot digest, and that may, perhaps, cause us pain. But the best reason why we should not eat the skin of fruit is that it has been exposed to the air, and contains a host of microbes. It is probably right to say that the business of the skin is to protect the fruit from microbes.

What Makes a River Wind?

WE should naturally expect that a river would flow straight from its source in the high lands or mountains to the nearest point in the sea, and so it would if it had to flow over a perfectly smooth surface, composed of glass, or of anything else of the same structure throughout. But the water has to flow over the land, and this is by no means smooth all the way, nor is it of the same composition all the way. The river flows the *easiest* way. When it comes to an obstacle such as a rise in the ground, it will be turned to one side and flow round it.

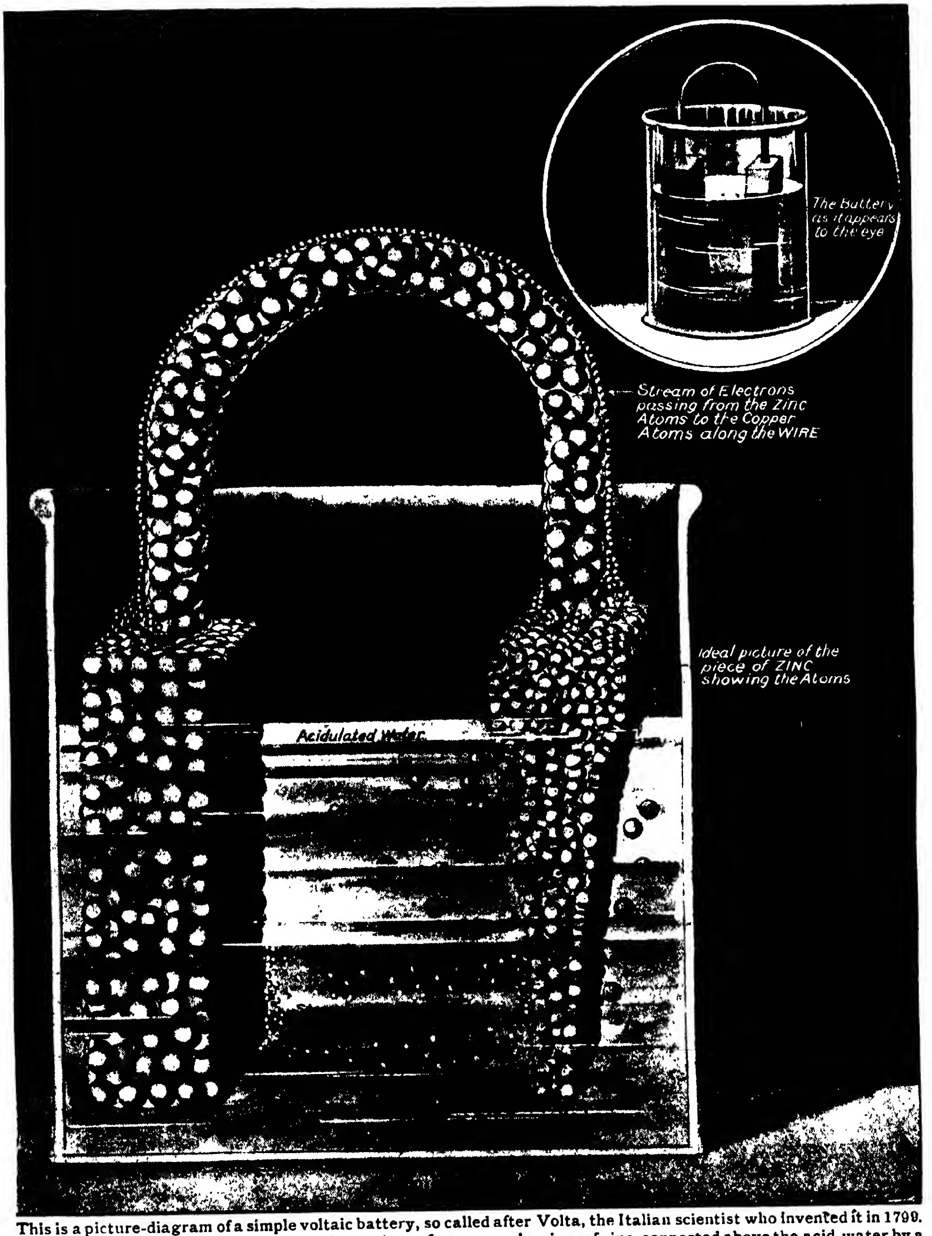
But, even when flowing through flat country, a river winds about, and this is because it washes away the soil from the softest parts of the surface and so makes a track for itself, which is followed by the water coming after. This is the "bed" of the river. Where the river comes to stone and rock, it flows over them until it reaches a softer part at the side, when it makes a track there. In this way deep cuttings are made in the earth by the constant flow of the water, and the softer the soil is the deeper the banks will be. As the soil is deposited in patches here and there, the flowing water finds these out and winds about them on its course.

Why Are the Rivers Never Still?

A RIVER is never still because of the great law of universal gravitation, which is that every particle of matter in the universe attracts every other particle with a force in the direction of a straight line joining the two. Now, as far as our earth is concerned, this means that the particles of the earth, and those of the water of a river, are thus acting towards each other, but the earth is the stronger, so to speak, and draws the water downwards to the lowest point it can reach.

That is to say, gravitation is acting in one direction, downwards, and this downward force of gravitation is what we mean by "weight." The particles of a river are always being attracted to the earth in this way, and so are always in motion, ultimately reaching the lowest level at the sea, which remains fixed in its position in accordance with the same great law. The rivers, we may say, are always moving because they are always trying to reach the sea, which lies at the lowest possible level, or the nearest point to the centre of the earth, which water can reach.

WHAT HAPPENS IN AN ELECTRIC BATTERY



This is a picture-diagram of a simple voltaic battery, so called after Volta, the Italian scientist who invented it in 1799. It consists of a jar of weak acid, containing a piece of copper and a piece of zinc, connected above the acid-water by a length of wire. The artist here shows us what is believed to happen in the battery when electricity is generated. The acid loosens the atoms of the zinc, which break away, and as the piece of zinc gets smaller and smaller the electrons in it become overcrowded. As a consequence they move off the zinc on to the connecting wire above, and flow in a continuous stream to the copper and then back again to the zinc through the acid, which is a good conductor of electricity. This goes on so long as the acid continues to eat away the zinc, and thus a constant current of electricity is kept up. If the piece of copper be lifted out of the acid, the current is broken, because air is not a good conductor of electricity, and the flow of electrons stops. The connecting wire can be extended to a great length, and if the copper and zinc be connected with the earth at their other ends the current will flow through the earth back to the zinc. In this picture the electrons are shown only on top of the connecting wire, but actually they are all round it.

What is Co-operation?

Co-operation is derived from two Latin words which simply mean working together. The usual opposite of co-operation is competition, and the whole point lies in the different results of these two things. In competition men behave as they do in a race, each trying to be first and to beat all the others. That is all right in races, and in many ways it is right and necessary, up to a point, in the race of life.

But often it is very harmful to the competitors and others. Perhaps the worst kind of competition is between the people who have money to employ others with, and the people whom they employ. This is often called the fight between "capital and labour." At its worst it does terrible harm to everybody concerned in it, and to the rest of the nation as well, for the nation is a whole, and what injures any part of it injures it all.

It is to remedy the dangers of the various kinds of competition and the evils which often result from it that nowadays men are trying to set up a system of co-operation, the idea of which is that there shall be no race, with a prize for the winner and nothing for the others, but something more like a game in which a team try to do something together—say, climb a mountain—and help each other. There are many kinds of co-operation, but perhaps the most valuable and promising is that between employers and those they employ. Genuine systems of co-operation in such cases mean that the workman shares in the profits of the business and has an interest in working well, and the employer's interest is to care for his workmen and treat them properly. There is a great future for this idea.

Could all the Worlds Come Together?

It has often been asked why gravity does not bring the stars down to the earth, or take the earth up to the stars, which would be nearer what would happen, for the earth is small and the stars large, and the greater part of the moving would be done by the earth. In the same way, when the large earth attracts a small cricket-ball, the cricket-ball also attracts the earth, and both move, but almost all the moving is done by the ball.

Gravity does have an effect on all the stars, including our sun, which our earth follows and must follow wherever he goes. If gravity were the only force in the world all the stars and planets and comets and nebulæ. and shooting-stars would soon rush together into one huge ball, and they always tend to do so. But though gravity is always acting, so are many other forces, especially the force of the motions which the various heavenly bodies have already. If all the heavenly bodies lost their force and suddenly stood still for a moment, they would then all start moving towards each other and come together. The moon would fly to the earth, earth and moon to the sun, and so on.

This result may follow some day if, as many suppose, the heavenly bodies are gradually slowing down and losing the force of their present motion. Or, rather, it would follow were it not that there are other forces in the world which act in directly the opposite direction to gravity—forces not of attraction, but of repulsion. We may believe that, on the whole, these opposite forces probably balance each other from age to age.

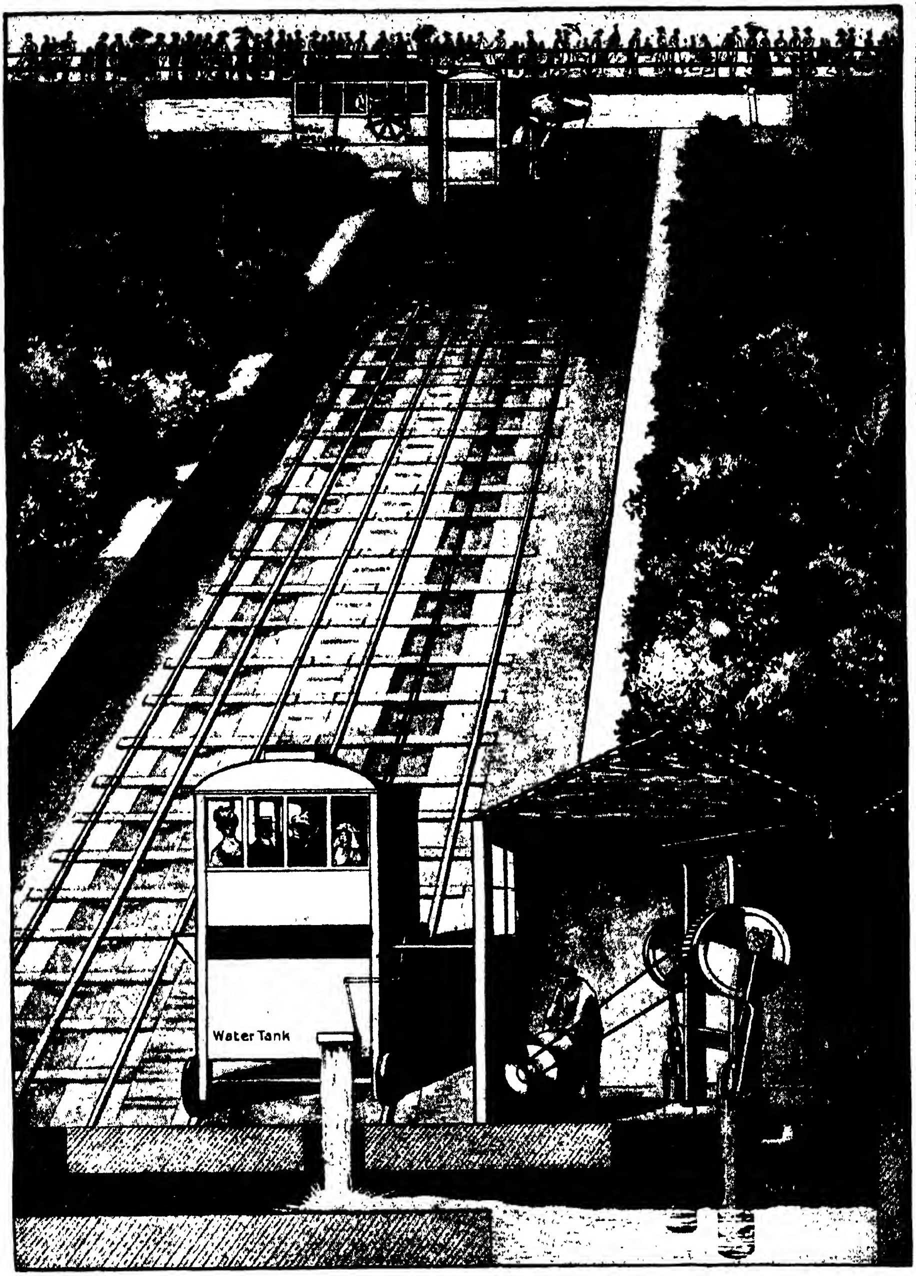
Why Does the Seaside Make us Brown?

There are two sensible ways in which we may explain why people's faces get brown. One is that the brownness increases the value of the skin as a protector of what is underneath it—a protector from salt air, and from waves of light and heat, visible and invisible.

Another explanation is that there are certain cells in the skin that have the power of making brown substance, and that these cells act when something excites them—when they are *stimulated*, as we say. We may put these two explanations together, and say that there are cells in the skin that have the power and the duty of producing a protective brown substance, and that their powers are called forth by those very things against which protection is desirable.

Wind, sun, and salt in the air are things that we meet at the seaside, and they are just the things that produce this brown colour. This brown stuff, like all the colouring of our bodies, is produced from the red colouring matter of the blood, and one reason why people brown so readily at the seaside is, perhaps, that they are healthier there—that their blood is richer in this red colouring matter.

HOW A CAR RUNS UP A CLIFF



This picture shows how most of the cliff railways at our seaside resorts are worked. Two cars, each with a large water-tank, are connected by a double rope that goes round a horizontal wheel at the top of the cliff. A car arrives at the top with its tank empty. This is filled with water, the brake is released, and the car descends by its own weight, pulling up the other car, whose tank is empty. When the car gets to the bottom, a lever is touched by a rod projecting from the pump-house, and the water is released. Meanwhile the upper car has its tank filled, and then descends, pulling up the lower one. From time to time the released water is pumped to the top of the cliff for further use. If both ropes should break, the cars would be held by clutches that automatically grip a middle rail.

Would a Thimbleful of Radium Drive a Ship?

THIS seems quite an absurd question to ask, for how could a thimbleful of radium, or anything else, have the power to drive across the Atlantic a great ship almost as big as a small town? And yet we find that radium has a marvellous amount of power inside it, and lately it has been possible to measure this power.

Of course, it does not follow that we can actually turn the power of radium to such a use as driving a ship, for that is another question. But it is most important to know that the power is there.

It is found that radium constantly gives off heat and light and other things at a certain definite rate, so definite that nothing seems able to make it eithr faster or slower. The heat can be precisely measured, and thus we can estimate roughly the total amount of power in any quantity of radium. It would need only a very small quantity, perhaps only a thimbleful, to drive an Atlantic liner, if we could get all the energy out of it in time. But the fact is that it takes thousands of years for radium to give out all its power, and, so far, we are utterly unable to hurry it up.

How Did Life Come to the Earth?

OF course, the first question really is whether life came to the earth, or started of itself upon the earth. And at present there are some people who believe the one and some who believe the other. Not long ago there were some very great people indeed who thought that life might not have started on the earth, and might have been brought here from somewhere else.

If that were so, we should expect that some tiny living beings had been brought to the earth from another planet by means of a meteorite. Certain meteorites might really be fragments from "the moss-grown ruins of another world," and might thus bring life to the earth, buried in their interior. Recently it has been argued that, apart from meteorites, living germs could be driven through space by the pressure which light has.

But whatever meteorites or the pressure of light could do, most people are now sure that living germs could not stand such treatment; and to say that life started in some other planet, vastly different in its details from our own, and yet was suitable for the earth, is not only exceedingly improbable, but leaves us still with the question: How did life start there? Now, that question, if it must be answered, is as likely to be answered from the earth as from any other planet; and that answer may be forthcoming in a few years.

What is the Law of Supply and Demand?

THE law of supply and demand is a very famous law as to the production of things that people want. The rule is that the supply of a thing and the demand for it always tend to become equal. We expect the demand to come first, and that creates the supply. The public demands actors, or novels, or bicycles, and it gets them. But it does not pay to produce what there is not enough demand for; and therefore, while the supply always tries to equal the demand, it usually stops there.

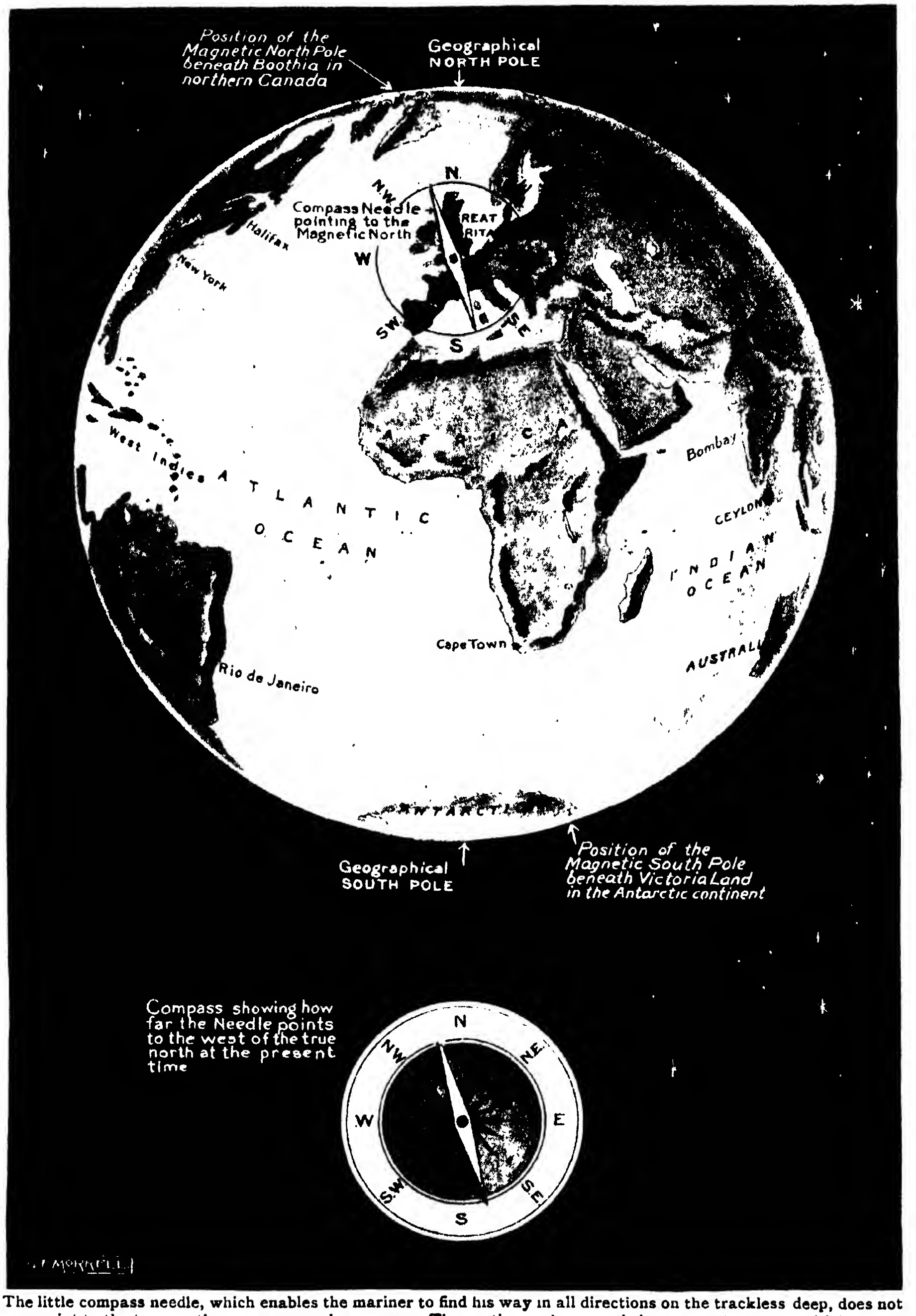
Since the law of supply and demand was first discussed, men have come to learn that it does not cover as many cases as we used to think. For instance, we know that the supply may create the demand if the supplier sets the right way about it. The demand for many things is very unequal, and may be made or destroyed by advertisement, and by anything that disturbs public opinion. The simple action of supply and demand is best seen in the case of necessaries like bread, or boots, or clothes.

But, above all, we must learn that a country is not necessarily prosperous and happy and wise because there is much demand in it, and an equal supply. The all-important question is *what* is demanded and what is supplied—music or music-halls, wheat or whisky, Wordsworth or the "sporting" newspapers?

Who was the Man who Lived in a Tub?

"THE man who lived in a tub" was Diogenes, the famous Greek who lived in the time of Alexander. It is quite probable that we should call him mad nowadays, but in any case he has made himselt famous for all time. He is said to have lived to the age of ninety, and, despite his very unpleasant manners and sayings, he was much admired. We all know the story of his going about the streets of Athens in broad daylight with his lamp lit, saying that he was looking for a man. He is commonly supposed to have said that he was looking for an honest man, but that is a mistake. His point was that people who lived ordinary lives were not worth calling men, and that was why he set out to find one.

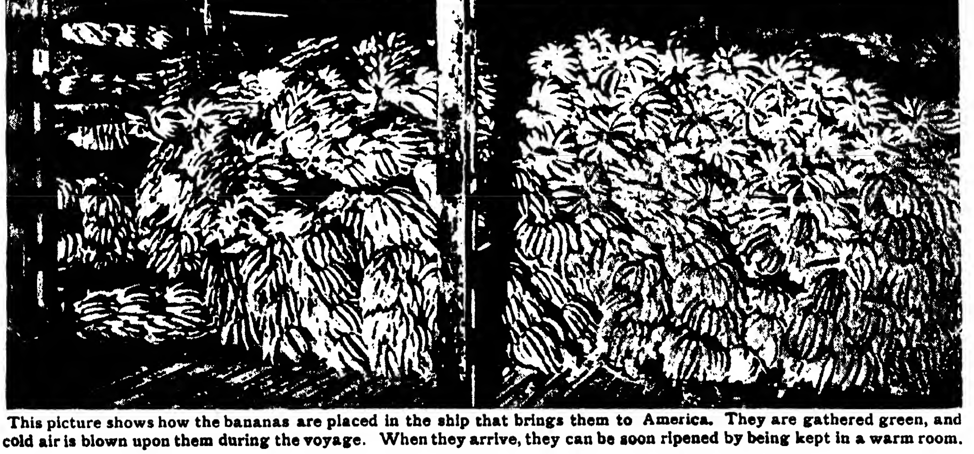
THE NEEDLE THAT GUIDES THE SAILOR



The little compass needle, which enables the mariner to find his way in all directions on the trackless deep, does not now point to the true north, as many people suppose. The earth may be regarded as a great magnet, with its poles somewhere in the interior, but not quite opposite to one another. In England, the south pole—that is, the north-seeking pole—of a magnetic needle points through the earth to the north magnetic pole, which is to the west of the true north pole. As we travel west, the needle points more and more to the true north, until in Eastern Canada it does so exactly. Every year the position of the magnetic pole varies, and at present it is approaching due north.

HOW THE BANANAS GO BY LAND AND SEA

The method of gathering bananas is practically the same wherever they are grown, and here we see the bunches being brought to the railway by coolies in Ceylon. It will be seen that a large part of the stem has been left on each bunch.



This picture shows how the bananas are placed in the ship that brings them to America. They are gathered green, and cold air is blown upon them during the voyage. When they arrive, they can be soon ripened by being kept in a warm room.

HOW WE GET THE BANANA

A MARVELLOUS PLANT THAT GROWS ALMOST BY ITSELF

To speak of the banana as having arrested civilisation may seem very absurd, but it is by no means so ridiculous as it seems. If there is one outstanding fact of human life which is generally regarded as sure and certain, it is that which was expressed so bluntly by Paul when he said, "If any man will not work, neither shall he eat." We all regard work as a necessity of existence. The need for food awakens industry, and industry calls forth the best and highest powers of the human race. Civilisation is really the product of hard work, and without the necessity of working man would never have become civilised at all; he would never have developed his intellectual powers.

The truth of this can be actually proved, for there are living to-day people whose food, in the form of the banana, grows in such plenty at their doors that they have merely to pluck it and eat it, and can live practically the whole of their days without working. But, instead of Nature's bountiful generosity proving a blessing to them, it has been nothing but a curse. The ease and profusion with which the banana grows has made the natives hopelessly and incurably lazy, and has caused them to remain in the condition in which they have been for generations—only slightly raised above the lower animals.

In this way the banana, by its wonderful productiveness, has actually arrested the progress of civilisation in many parts of tropical America, where the people, finding food in such abundance, without the necessity of working to produce it, simply live to eat and sleep, and make no exertion for anything above a mere animal existence.

It is a curious fact that the banana, although the most prolific of all fruits, nowhere grows wild. It has to be cultivated, and yet the cultivation that it needs is so trifling as scarcely to count; for all that is required is to remove the unnecessary suckers thrown up by the root, so that all the energy of the plant may be put into one stem and there produce a plentiful supply of fruit.

The banana grows abundantly in the tropical parts of America, and most of our bananas come from the West Indies; but it is not a native of the New World, and there is some doubt as to whether it was found there when Columbus made his great discovery. If so, it had probably been carried there from the Old World by ocean currents. But the general opinion is that it was taken to America from the Canary Islands by Spanish and Portuguese settlers.

There are no fewer than 176 different kinds of bananas, most, if not all, of them being good for food. The one that we buy in our fruit-shops is the most common and also the most nourishing and delicious. A very distinguished English doctor said the other day that he wished all school children could have bananas from time to time, for they contain all the necessary elements for supporting life; and there is no doubt that if boys and girls would spend their pennies on bananas instead of sweets, they would be much stronger and better for doing so. Like oranges, the fruit is protected from dirt and impurity by its skin, which is a very great advantage where it is sold in towns.

The number of uses to which the banana can be put is amazing. It is unique among food-plants in this respect. The young sprouting leaves when boiled make an excellent vegetable for the dinner-table. The fruit can be eaten raw, or dried in the sun like figs, and it can be cooked in a hundred different ways. It makes a delightful jam, and from the juice, squeezed out, is made a very good wine that tastes something like cider. The dried fruit, ground into meal, forms a good flour for the making of bread and biscuits; and an expedition that went into Central Africa some years

ago to search for Emin Pasha lived for a long time entirely upon it. The full-grown leaves, which are often ten feet long and two wide, are used for thatching houses; from the stem a medicine is made, and an ointment from the leaves. The fibre of the leaf-stalks is woven into canvas for the making of sacks and mats and even clothes; and the fibre also produces a very good and strong rope. In fact, the banana has been called the maid-of-all-work of the vegetable world. In the East it is known as "the food of wise men."

At weddings in many parts of India bunches of bananas and leaves of the plant are carried as symbols of the plenty which it is hoped the bride and bridegroom will always enjoy; and surely no more apt symbol could be chosen, for a single acre will produce 35,000 bananas a year, almost sufficient to provide a hundred bananas a day. This it will go on doing for seven years without the necessity of once having the soil manured or fed in any way.

THE MAN WHO INTRODUCED THE BANANA TO THE ENGLISH PEOPLE

Of course a pound of wheat contains more nourishment than a pound of bananas, but the great traveller Humboldt declared that the banana is about 133 times more productive than wheat, and 44 times more than the potato—that is, a plot of ground that will produce only one pound of wheat and three of potatoes will produce 133 pounds of bananas. Thus, a much greater number of people can live on a piece of ground planted with bananas than on a similar piece planted with wheat.

Twenty-five years ago the banana was almost an unknown fruit in England, but now, in a single week, sometimes more than seventeen million bananas are brought to London from the West Indies. Many steamers are constantly going backwards and forwards simply to carry bananas, and some of the English railway companies have built special carriages to take these throughout the country.

This remarkable change in a quarter of a century was brought about by the energy of one man, the late Sir Alfred Jones, a great shipowner, who, knowing the tremendous value of the fruit as food, saw the possibilities of the banana trade. To introduce the fruit to English people, he at first carried it free from the Canary Islands; then brought it from the West Indies, and now the banana is one of the principal exports to England from Jamaica.

In Central America the banana is extensively grown for export, and some of the farms are twelve thousand acres in extent. To see a great tract of country all covered with banana plants is a magnificent sight.

THE ENORMOUS PLANTS THAT ARE CUT DOWN AT A SINGLE STROKE

The banana needs a warm, damp atmosphere, with plenty of water, either as rain or from artificial irrigation. The land is first cleared of all its trees and undergrowth; parts of the roots of old banana plants are then planted in little hillocks, four or five roots to each hillock, and only one stem is allowed to grow from each root, the other suckers being cut away. In ten or twelve months the plant is fully grown, and its stem bears only one bunch of about a hundred to a hundred and thirty bananas. Presently the fruit-stem is thrown out and bears a beautiful red blossom.

An expert goes round the farm marking those plants whose fruit is ready for cutting, and then the stem is cut down with one stroke of a machete, a kind of weapon, half sword and half knife, that is used for all kinds of purposes in the West Indies and in some parts of Central America. The bunch of fruit is then cut off, and the stem left to decay upon the ground.

The women of Jamaica are very expert in carrying things on their heads, and can convey a heavy bunch of bananas in this way many miles without once stopping. Even the Jamaican children are taught to carry things on their heads as soon as they can walk, and boys and girls may often be seen running about playing touch with their school-books and ink-pots on their heads.

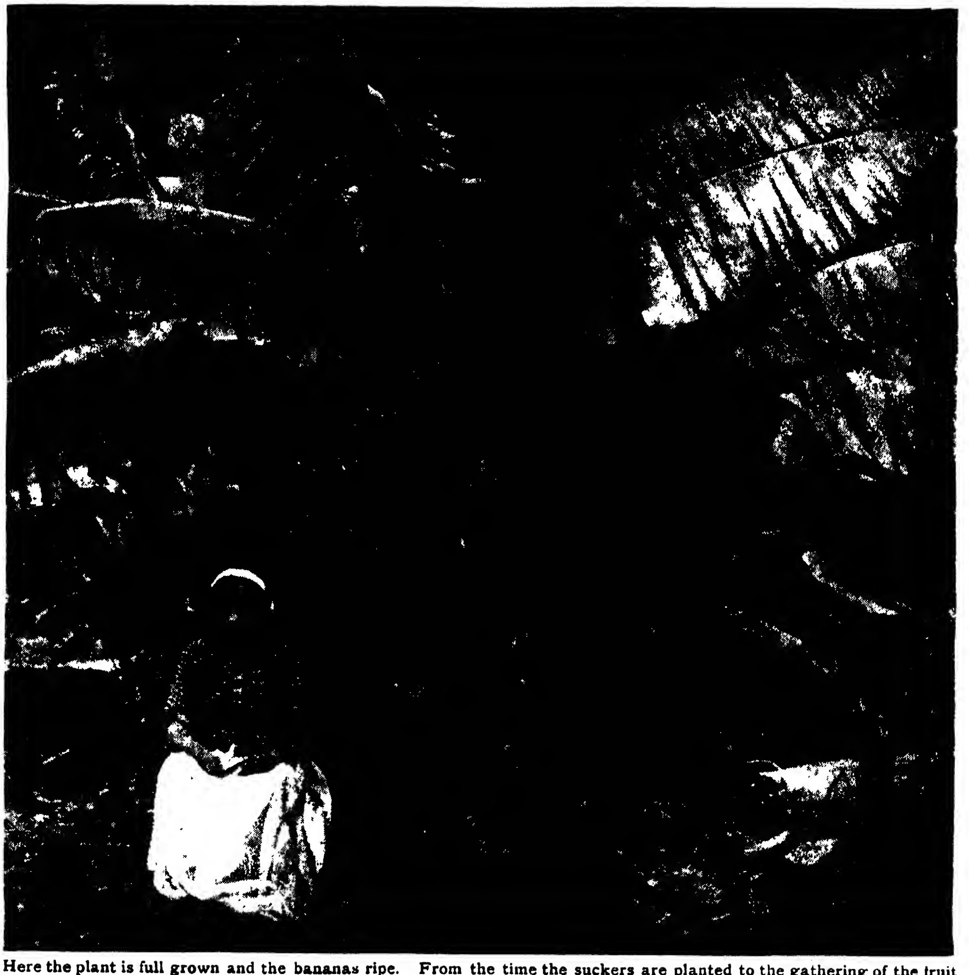
THE COLD AIR THAT BLOWS ON THE BANANAS AS THEY CROSS THE SEA

During their voyage to England the bananas have cold air blown upon them by machinery, and when they arrive they are still as green as when they were picked. A short time in a warm room or warehouse soon ripens them for the market, and thus we get them in England in as delicious and fresh a condition as a native of Jamaica can pick them from the plant. Some of the ships engaged in the banana trade can carry more than six million bananas on one voyage.

No banana that is at all green, even only slightly at the ends, should ever be eaten. It should be kept until the whole of the skin is yellow; and although bananas that are soft may not appear so nice to the eye as those that are firm, they are better for eating.

HOW THE BANANA PLANT GROWS

The banana plant is the most wonderfully productive fruit in the world. It is a native of Asia, but most of our bananas come from the New World. In this picture we see labourers planting suckers of the banana plant on a farm in Ceylon.



Here the plant is full grown and the bananas ripe. From the time the suckers are planted to the gathering of the fruit is less than a year, so rapidly does the plant come to perfection. This photograph was taken in the Canary Islands.

THE WATER THAT GIVES LIFE TO THE BANANA

Bananas need a great deal of water. They will only grow in a warm, damp atmosphere, and if much rain does not fall they must be supplied with water artificially. This is done by having canals between the rows of plants, as shown here.

Jamaica, which supplies most of the bananas that go to England, is an ideal country for banana-growing. The country is specially suitable, and the island is abundantly supplied with rivers. Here is a typical stream in the banana country.

CUTTING DOWN THE HUGE STEM AT ONE STROKE

As soon as the fruit is ready for gathering, a man climbs up the great stem of the banana plant, as shown on the left, and with one slash cuts it down. The bunch of fruit is gathered, and then, with another cut, the stem is struck off, as on the right.

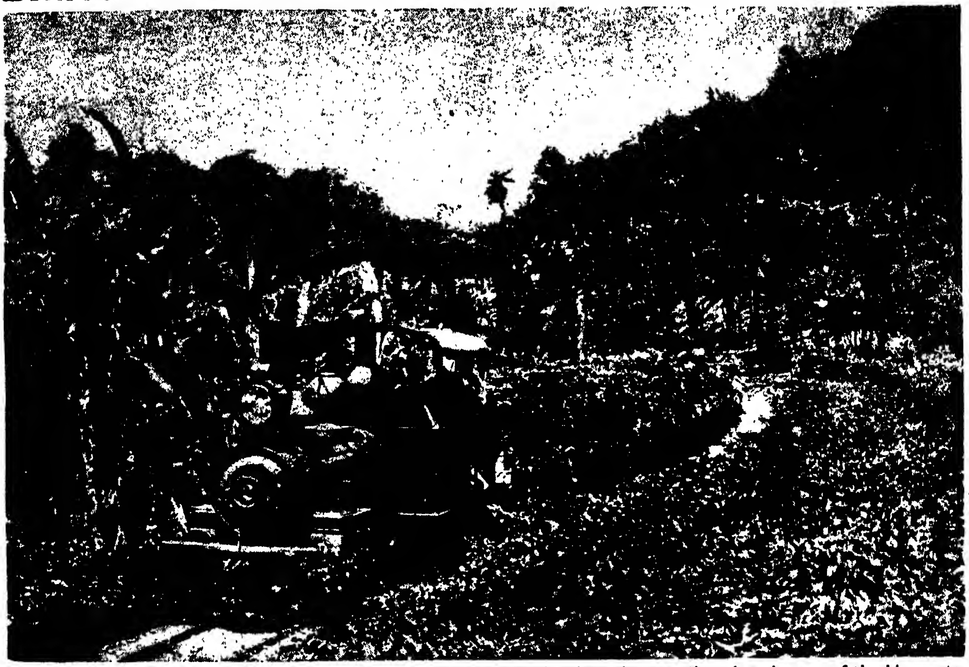
This picture shows how the stem falls when it is first cut down ready for the bunch of fruit to be gathered. In the West Indies and America the cutting is done with an instrument called a machete, which is something between a sword and a knife.

GATHERING THE FRUIT ON A BIG FARM

Some banana farms cover two v thousand acres, and hundreds of labourers are employed. Here we see another way of cutting down the bunches on a big farm in Jamaica. After the fruit is gathered, the stems are always cut to the ground.

There are different ways of getting the bananas to the railways. Sometimes they are carried on the heads of women, and sometimes on mules, as shown in this picture. Many farms have light railways, as seen in the upper picture.

BRINGING THE BANANAS TO THE RAILWAY



No time must be lost in getting the bananas to the railway after they have been gathered, and many of the big, up-to-date farms have little railways of their own like the one in the picture, the trains running between the rows of plants.

Where the farms have no locomotives they often have narrow tracks laid down in the plantations, as a mule can draw a much heavier load in a wagon running on rails than he can carry on his back. Here we see one of these primitive railways.

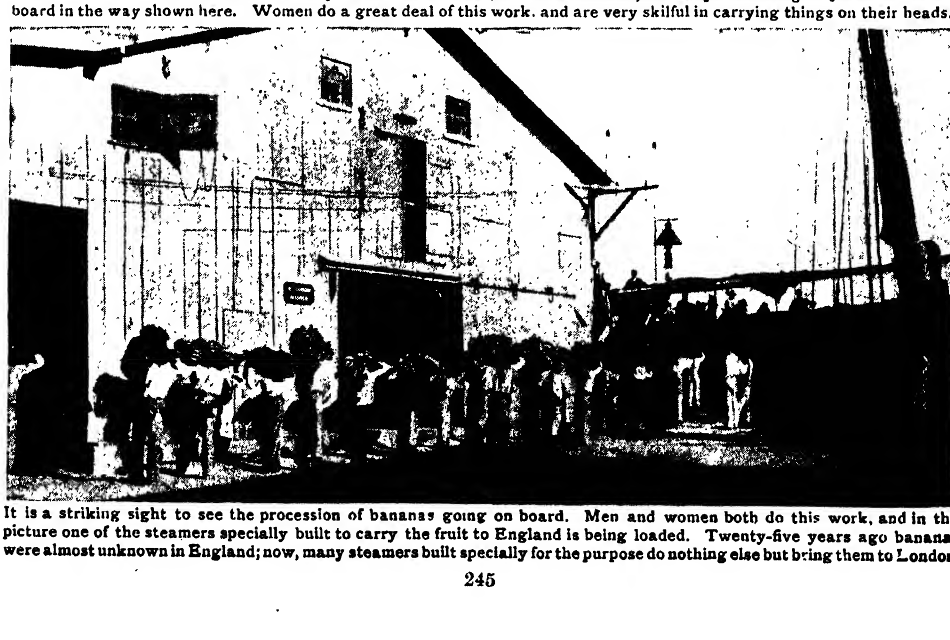
A MILLION BANANAS READY FOR LONDON

Here a great harvest of bananas has been brought to the railway ready for transport to the docks, where the fruit will be shipped to London. A bunch has about a hundred bananas, and here there are something like ten thousand bunches.

In this picture bananas are being loaded into the railway waggons that will carry them to the ship. The banana trade is now an enormous industry. Ten million bananas sometimes come to London in a week, mostly from Jamaica.

THE PROCESSION OF BANANAS TO THE SHIP

On arrival at the docks the bananas are placed in warehouses, and when the ship is ready for loading they are carried on board in the way shown here. Women do a great deal of this work, and are very skilful in carrying things on their heads.



It is a striking sight to see the procession of bananas going on board. Men and women both do this work, and in the picture one of the steamers specially built to carry the fruit to England is being loaded. Twenty-five years ago bananas were almost unknown in England; now, many steamers built specially for the purpose do nothing else but bring them to London.

HOW ELECTRICITY MAKES THE TRAM GO

We have all seen the opening between the tram-lines, and here we see the conduit below. In this underground channel are two rails charged with electricity. Hanging from the car is a sort of brush, called a plough, which brushes against the sides of the live rails, picking up electricity from one of them. The electricity is carried to the end of the car, passing into what is called a circuit-breaker—an emergency provision by which a circuit is instantly broken if the current becomes too powerful. The current then runs through the controller into the motor. It drives the motor at a tremendous speed, and the motor drives the tram. The electricity, having now served its purpose, completes the circle of its journey, returning by a parallel route until it reaches the second rail in the conduit, which carries it back to the power station. Thus an endless circle of power, unseen by anybody and unthought of by most people, has carried a tram through miles of streets.

What You Should Know

ABOUT A TOP

We all love tops—at some time or other. What clever things we used to do with them! What we did not know about tops was hardly worth knowing, we used to think.

Well, here are some things about tops that perhaps we never think of when we spin them, good for us all to know.

TOPS have been described as the most interesting of all toys. There are people, no doubt, who think of a top as only a toy for children, but the top is really a most valuable means of studying scientific laws and principles, and some of the greatest philosophers have not disdained to give it their profound attention.

A poet who lived about the same time as Jesus describes a party of youths amusing themselves by keeping a whipping-top spinning, and there is no doubt that many a budding scientist has had his attention first drawn to the laws of motion by watching the spinning of a top.

But, before we give it any motion at all, the top will afford us an excellent lesson in physics, by showing us, in different positions, the three forms of equilibrium, or balance. Let the top rest on the ground, with its peg uppermost, and we see stable equilibrium—that is, a condition in which, after any slight disturbance, the top will return to its original position. Balance it on its peg, and it is in unstable equilibrium—that is, a state in which any slight disturbance will make it change its position. Place it on its side, and it is in neutral equilibrium—that is, a state in which, if moved, its position relative to the horizontal surface on which it rests is unchanged.

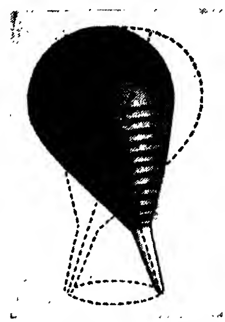
Now let us spin a peg-top by uncoiling rapidly a string wound tightly round it for the purpose. The string is held round the sides of the top by adhesion, but by a sudden jerk we overcome this, and, as the string is pulled, friction is set up between it and the top, so that it turns the top in the direction opposite to that in which the string is moving. The more rapidly we pull the string the better will the top spin, owing to the greater rotating movement we give to it. When we keep a top spinning by whipping it, the same thing happens. The lash of the whip winds more or less round the top, and, as it is pulled away, the friction gives the top a fresh spin.

When a string wound tightly round any part of a top is pulled, the top would go with the string, unless there were some resisting force to prevent it doing so. In humming-tops this resistance is given by the left hand holding the handle of the top while the right hand pulls the string. In the spinning of a peg-top, the top is hurled towards the ground with some force, and the momentum thus given to it carries it down while the string is pulled rapidly upward. The resisting force in this case is the movement of the top towards the ground.

When we spin an ordinary peg-top, the force with which we throw it towards the ground carries it along horizontally for a certain distance, and then it begins, in addition to its spinning or revolving motion, to run round slowly on the point of its peg, forming a circle or spiral, which gradually gets less and less until the top at last spins in an upright position and appears almost motionless. In this condition boys say it is "sleeping," and the rotating in an ever-narrowing spiral they call "wobbling." The top, in its early spinning, has thus two distinct motions—it revolves rapidly round its own axis, and it "wobbles" or rotates slowly so that the point of its peg forms a circle on the ground.

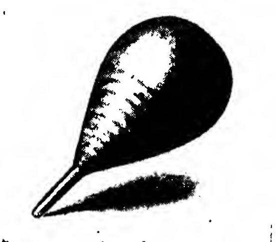
Now, why does the top wobble? And why, after wobbling, does it raise itself upright? Well, the wobbling when it first spins is caused by the friction of the ground. If there were no friction and no atmosphere, the top would continue to revolve, or spin on its own axis, at whatever angle it happened to touch the ground, and would neither wobble

nor raise itself. The way science puts this is that "the axis of any rotating body has a strong disposition to permanency." We may not know this law, but we take advantage of it every time we throw a quoit, for we purposely give the quoit a twirl to make it revolve as we send it on its errand. This spinning keeps the quoit in one attitude throughout its journey, and the flight is thus much truer than if we merely threw the quoit and allowed it to wobble towards its mark. Such a throw would make it very difficult, if not impossible, to hit the mark. On an infinitely grander scale we have the rings of Saturn preserving their position in relation to their planet, because they are spinning round all the time they are journeying through space.



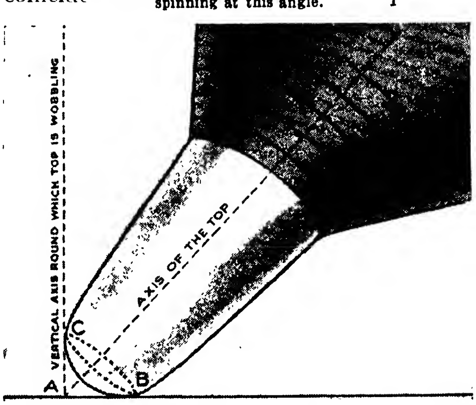
THE WOBBLING OF THE SPINNING TOP

In addition to revolving, a top runs round on its peg, forming a circle or spiral, which gradually grows smaller and smaller.



If there were no friction and no atmosphere, a spinning top meeting the ground like this would go on spinning at this angle.

Modern guns and rifles fire shells and bullets with far more deadly precision than the old-fashioned weapons because this law of motion is taken advantage of. The bore, or inside of the rifle-barrel and gun, has spiral grooves cut in it, which give the bullet or other projectile a rotary motion, and so when the centre of gravity of the bullet does not coincide exactly with its longitudinal axis, and its passage through the air would consequently be wobbling and very erratic, the rapid rotation given by the spiral groove, or rifling, makes the flight accurate. The rotating of the bullet prevents any wobbling, and this fact, of such tremendous importance in modern warfare, men have learned from the spinning top.



A MAGNIFIED DIAGRAM OF THE END OF THE PEG OF A TOP

The rounded point of a top's peg runs on the ground very much as a hoop bowls along. The top here rests on B, which is retarded by friction; but C, the top of the hoop, rushes round, and thus the whole circle through B and C meets the ground, and the whole top wobbles on this circle round the vertical axis, until at last the axis of the top coincides with the vertical axis, and the erect top spins on its point at A.

The wobbling of the top when it first spins is brought about by exactly the same force that causes a hoop or a ball to roll on the ground instead of simply moving forward without any rotation. Take the hoop. We project it forward by a blow from the stick, but friction, caused by the roughness of the ground, acts on that part of the rim which is touching the ground for the moment, and retards its speed. The upper part of the rim, however, is not suffering from friction, and continues to move. It cannot go forward without the rest of the hoop, and so it has to move down until it, in turn, touches the ground and is retarded. The part of the rim that was formerly in contact with the ground is now free from friction, and is able to move without hindrance, and so, in turn, each part of the rim comes to the ground, and the hoop is kept rolling, instead of merely moving horizontally forward.

Now, the end of the top's peg, though it may seem a mere point, is really like the hoop; in fact, if you took a section of it you would see it to be a round disc, which is only a solid hoop. When the top is spun, striking the ground at an angle so that it leans over, it is not spinning on the extreme end of its axis, but on a point a little to the side. Look at the magnified point of the peg in the picture. For a moment the top rests on the point B. The friction of the ground retards this point, but the circle round this part of the peg, like all the rest of the peg and top, is revolving, and so, as in the case of the hoop, another part of the circle, not in contact with the ground, moves forward, to be also affected by the friction of the ground, while the point B moves on to C. The result of this is a rolling of the top round an imaginary perpendicular line, as shown in the picture, this motion round A, the centre of the circle on the ground, being quite independent of the revolving of the top round its own axis.

Men of science have discovered that one of the laws governing the spinning of bodies such as tops is that when forces act on the spinning body, tending to make it rotate about an axis other than that round which it is revolving, the spinning axis tends to set itself in agreement with the new rotating axis until both become the same. The reasons for this behaviour of the spinning body are far too complicated to be understood by any but those who have a deep knowledge of the higher mathematics, but it may be accepted by the reader as a demonstrated fact.

Now, the top is wobbling—that is, rotating—round an imaginary line perpendicular to the ground. It is also spinning, or revolving round its own axis, which is not perpendicular to the ground. According to the law of spinning bodies, which we have just seen, the revolving axis of the top should rise until it coincides with the imaginary perpendicular line round which the top rotates. And this is what it does, as every boy knows. The spinning top gradually assumes an upright position, and at last revolves so steadily that it is said to be asleep. In this condition it is in what science calls a state of mobile equilibrium.

When the top is nearly run down it begins to wobble again, but the reason for the wobbling is different now. The rapid spinning of the top overcomes the force of gravitation, and keeps it upright on its peg. But, as the speed slackens, gravity gradually asserts its sway, and the upper part of the top, where the greater weight, and therefore the centre of gravity, is situated, is drawn towards the earth. The result is that the top begins to wobble, and this increases until at last the sides of the top touch the ground, and the friction set up is so great that the top is brought to rest in a position of stable equilibrium.

It is in understanding the motions of the earth on which we live that the spinning top has proved of greatest service. Suppose, for a moment, that the laws which govern the movements of the top as it revolves were to be suspended. That may seem a matter of little importance. But the earth is also a great spinning top, and we should at once begin to find that the suspension of these laws meant everything to us. Our summers would become colder than our winters now, and our winters would become our summers.

It is the tilt of the earth—the slant of its axis—that is responsible for the relative temperatures of summer and winter. As is generally known, the earth is about three million miles nearer to the sun in winter than in summer, yet we get warmer weather in summer. This is due entirely to the tilt. In its journey round the sun, the earth, whatever position it may occupy in its orbit, always has its axis inclined at the same angle, and in summer this is tilted towards the sun, while in winter the slant is away from the sun.

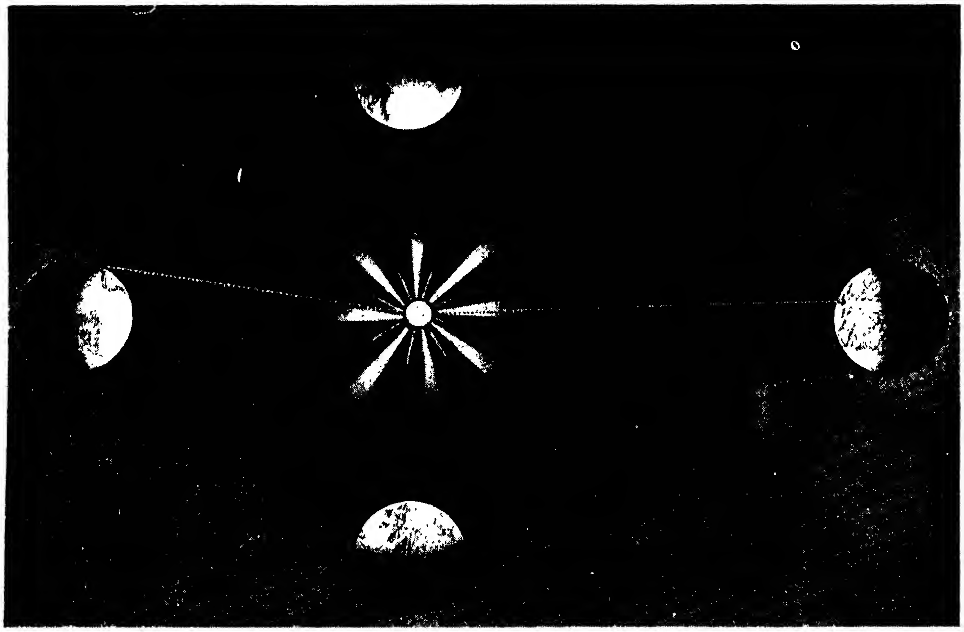
Now, the more directly the sun's rays fall upon any part of the earth's surface, the hotter they are; and so in summer, though we are farther from the sun than in winter, we in the northern hemisphere catch the rays more directly than in winter, when the axis slants away from the sun,

THE SPIN IMPARTED TO A QUOIT

In order to keep the ring of the quoit in the same plane and make it go straight to its peg, we give it a twirl as it leaves our hand. For the same reason we rifle a gun-barrel to give a bullet a twirl, so that it revolves on its axis, and goes undeflected to its mark. Without the twirl they would wobble.

or than we should if the axis were perpendicular. In other words, in summer the sun is more directly over our heads, and therefore hotter.

But why is the earth tilted in this way? Well, it is simply the wobbling of the great terrestrial top as it spins round on its axis; and if the laws which govern the wobbling of the peg-top and all other tops, small and great, were to cease to operate, the revolving earth would suddenly spin round in an upright position, and summer would be colder than winter. We should receive the sun's rays at the same angle at both seasons, but at the season which is now winter we should be nearer the sun than

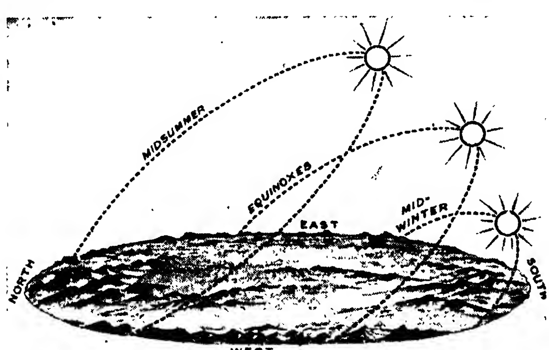


THE PRESENT TILT OF THE SPINNING EARTH

The axis of the earth is an imaginary line drawn from Pole to Pole, and round this axis the earth spins. Its tilt in our age is as shown in the diagram, with the result that England receives the sun's rays more directly in summer, when the sun is farther away, than in winter, when the sun is actually 3,000,000 miles nearer to the earth.

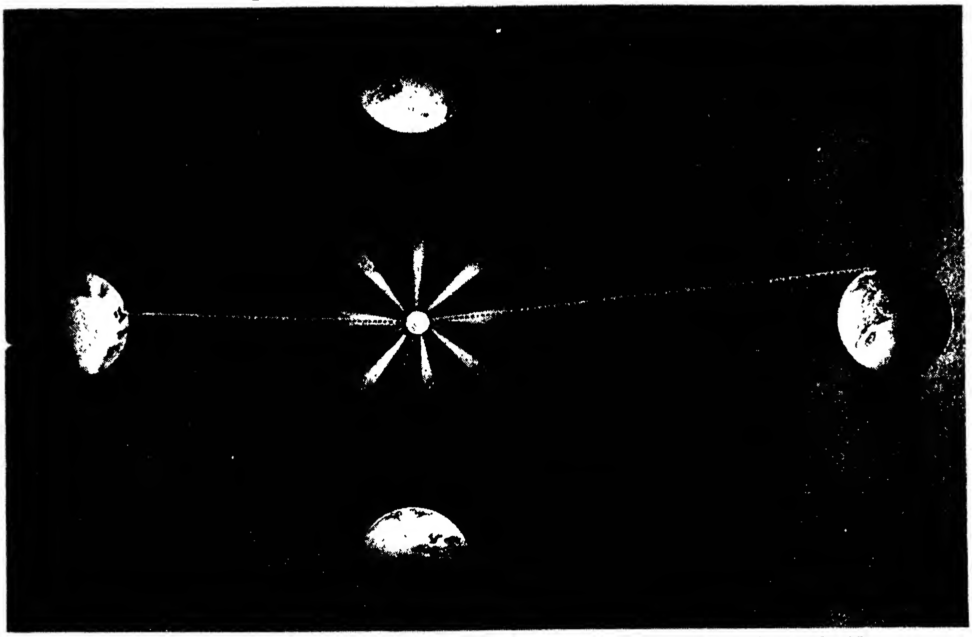
in our summer, and there would be no tilt to counteract this. It is the wobbling of the great earth-top, causing the tilt towards the sun in the summer so that we get his rays more directly than in winter, that gives us the warm weather we experience.

The earth is still wobbling like a newly spun peg-top, and in rather less than 13,000 years it will have wobbled, or *precessed*, as men of science say, about half a revolution, so that the axis will then be sloping towards the sun when the earth is nearest, instead of, as now, when it is farthest away from the sun.



THE APPARENT PATH OF THE SUN AS SEEN FROM ENGLAND AT MIDSUMMER, MIDWINTER, AND AT THE SPRING AND AUTUMN EQUINOXES

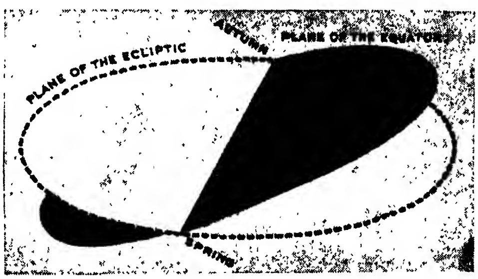
It is the wobbling of a top as it spins that explains simply what is known in science as "the precession of the equinoxes." The great circle the sun appears to describe round the heavens once a year is called the *ecliptic*, because it is in this circle that all the eclipses of the sun and moon occur; and the plane of the ecliptic is the plane passing through this circle. Imagine the earth and sun floating in a boundless sea, each half-sunk, as far as their centres. The surface of this sea would be the plane of the ecliptic. Now, the earth is tilted, and its axis would make with the surface of this sea—that is, with the plane of the ecliptic—an angle of 66½ degrees. Let us suppose another great plane passing through the earth's equator, and continued outwards in all directions to the sphere of the heavens. This is called in science the plane of the equator, and it does not, of course (as can be seen in the diagram), coincide with the plane of the ecliptic; the tilt of the earth prevents this. The two planes are inclined to one another at an angle of 23½ degrees, and cut one another at two opposite points. The two points are called the *equinoxes*,



HOW THE EARTH WILL TRAVEL ROUND THE SUN IN 13,000 YEARS' TIME

In the course of some thousands of years the spinning world will have wobbled half round and tilt in the opposite direction, so that the direct rays of the sun will fall on England at the period which is now our winter, when the sun is nearer the earth, so that our climate will be more extreme.

or equinoctial points. The sun in its apparent passage round the heavens is at these points on March 21 and September 23, and at these times the days and nights all over the world are of equal length, hence the name equinox, which means "equal night." The reason for this is that the earth's axis is, at the equinoxes, perpendicular to a line joining the centres of the earth and sun, and is really in the same relative position to the sun as if its axis were perpendicular. Any boy or girl can work this out, and prove it to himself by experimenting with a revolving globe of the earth and a lighted lamp.



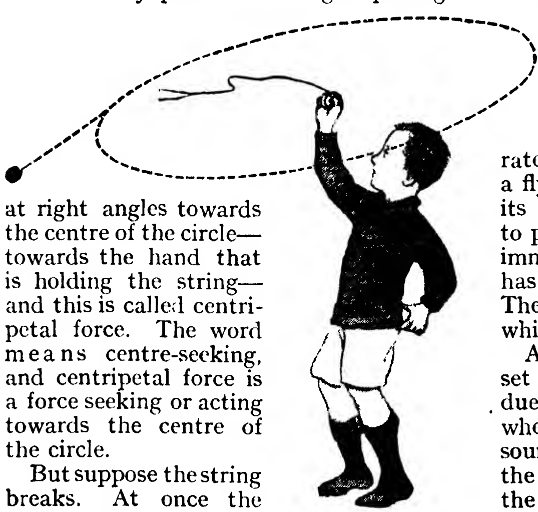
THE INTERSECTION OF THE PLANES OF THE EQUATOR AND THE ECLIPTIC. THE EQUINOCTIAL POINTS OF SPRING AND AUTUMN LYING WHERE THEY CUT

The two points of the ecliptic midway between the equinoxes are called the solstices, a word meaning "the sun stands." The solstices are the times at which the sun reaches its greatest distance from the equator, and the name was given because at these points the sun appears to stand still before the direction of its motion is changed towards the equator again. Now, with this knowledge, and the wobbling of the top, we are in a position to understand the precession of the equinoxes, a phrase that means simply the moving forward of the equinoctial points. Why do these points move or change their position on the ecliptic? If the earth were a perfect sphere, and uniform in structure, there would be no precession; it would simply revolve with the axis in an upright position. But as the earth has a greater diameter at the equator than from Pole to Pole—that is, having a belt, as it were, sticking out all round at the equator—the attraction of this by the sun tends to pull the earth into the plane of the ecliptic. The rotation of the earth prevents this, however, and, instead of the two planes coinciding, the spinning earth wobbles like a top. This, however, means that while the angle at which the plane of the equator is inclined to the plane of the

ecliptic remains about the same—namely, 23½ degrees—the direction of the plane of the equator shifts with the wobbling of the earth. The points of intersection of the two planes—the equinoctial points—are therefore constantly moving, and in about 25,800 years will have made a complete journey round the ecliptic.

If a top could be spun in a perfect vacuum, and all friction of the peg on the ground could be eliminated, it would go on spinning for ever at whatever angle the axis happened to touch the ground. To change the position of the spinning top some outside force is needed. In the case of a spinning peg-top it is the friction of the peg on the ground, and in the case of the spinning earth it is the attraction of the sun on the excess matter at the equator, where the earth's greater diameter is. In each case the result is the same—a wobbling motion.

A top is an excellent illustration of the two forces known as centrifugal force and centripetal force. If we tie a string to a stone and then swing it round, the stone will describe a circle. Its tendency at every point of the circle in which it is moving is, according to Newton's first law of motion, to fly off in a straight line. But at every point the string is pulling it



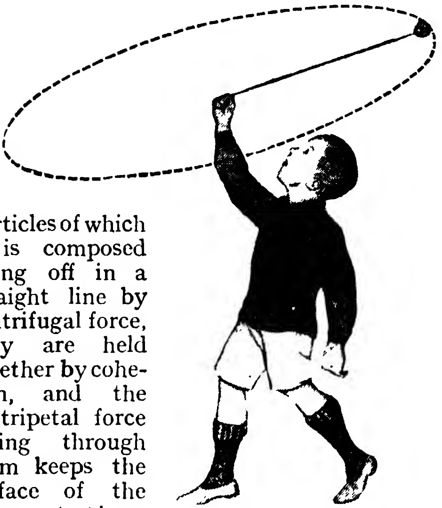
HOW THE STONE FLIES OFF

The string breaks, and the stone goes off by centrifugal force at a tangent to the circle.

at right angles towards the centre of the circle—towards the hand that is holding the string—and this is called centripetal force. The word means centre-seeking, and centripetal force is a force seeking or acting towards the centre of the circle.

But suppose the string breaks. At once the stone flies off in a straight line by centrifugal force, though centrifugal force is a bad name, for it means "fleeing from the centre." The stone, however, does not flee from the centre, but at a tangent from the circumference. A tangent is, of course, a straight line drawn so as just to touch the circumference of a circle without cutting it, even if prolonged.

When the top spins, instead of the various



THE CIRCLE DESCRIBED BY A SLING

The string pulls the stone towards the boy's hand, the centre of the circle, which is centripetal force.

particles of which it is composed flying off in a straight line by centrifugal force, they are held together by cohesion, and the centripetal force acting through them keeps the surface of the top rotating. But if, while a whipping-top is rotating, we drop some grains of sand upon its upper surface, they will immediately fly off in straight lines by centrifugal force, there being no connectiong link through which centripetal force can act upon them.

Sometimes, when an engine or piece of machinery is working at a very great rate, the centrifugal force acting on the rim of a fly-wheel overcomes the cohesion holding its particles together, and the wheel goes to pieces, its fragments flying off and doing immense damage. Workmen say the wheel has "burst," so suddenly does it fly apart. There is a limit, therefore, to the speed at which machinery may work.

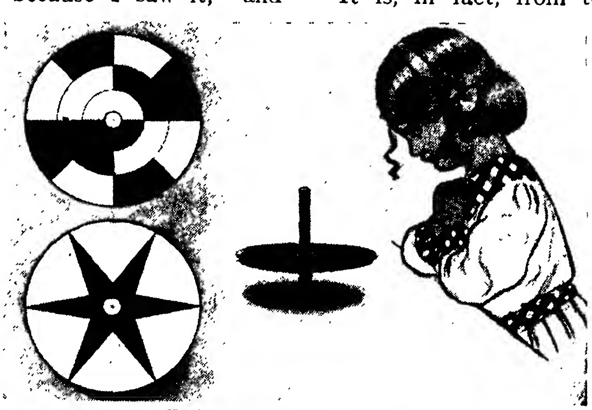
A word must be said about the sound set up by a humming-top. This is not due to the same cause as the droning heard when a shell is held close to the ear. All sound, as we know, is caused by waves in the air, the pitch of a note depending upon the length of the individual waves measured from back to front, and the loudness upon the depth of the valley intervening between the waves. Now, the sound of the shell is simply a confused medley of external noises, but the humming of the top is due to waves set up in the atmosphere by the top itself, which is so constructed with a series of holes as to produce waves of a certain length. Even a flute, if it

could be spun with great rapidity like a top, would produce certain sounds.

There is another kind of top from which we can learn something of the science of optics and what is known as the "persistence of vision." This top has a flat disc with a short peg and a spindle above, over which cards of various designs and colours can be dropped while the top is spinning. The cards spin with the top because, although they are separate and independent, they are held to the top by adhesion.

THE HUMMING-TOP AND THE SEA-SHELL
The top itself makes waves of sound, but the shell only collects sounds from round about it.

First of all some interesting effects can be obtained by using cardboard discs of black and white. One design is shown in the picture. When spinning with the top this loses its black and white divisions and appears a uniform grey. Why is this? There is an expression which is often used and which is generally regarded as being an unanswerable argument in a discussion. "I know that this is so," says a person, "because I saw it," and we have the proverbial phrase "Seeing is believing." But the evidence of the eyes is really a very questionable evidence, as this top proves. If we did not see the black and white discs at rest beforehand, we might be absolutely sure that it was a grey card, and as proof point to the evidence of our own or other people's eyes. But here is a case where seeing is not believing, for we see a grey card, but know by examining the card at rest that it is not grey, but has black and white designs.



THE SPINNING DISC TOP
These black and white discs become in the upper example a uniform grey, and in the lower a circle with dark centre merging to grey at circumference.

The explanation is that the retina of the eye retains for a moment or two any image which it receives. Now, this disc, it will be noticed, is so divided that the innermost circle is half black and half white, the middle circle has two black quarters and two white, and the outer circle has four eighths black and four white. When we revolve the disc rapidly on the spinning top, the impression of one black and one white section of each circle does not disappear from our retina before another is received, and so there is a series of continuous impressions of black and white mingling together and giving the grey effect which we see. If, instead of black and white, we use different colours, we shall get some interesting effects in colour mixture. A good example is that of a star of one colour painted on a disc of another colour. When this revolves rapidly with the top, the centre will have the colour of the star, and this will merge by various gradations into the colour of the background at or near the circumference.

It is, in fact, from tops of this kind, with discs of various colours and designs, that men of science have gained a great deal of valuable knowledge about the impression of light on the retina, and also about the mingling of colours. Some of the tops go by the names of the learned men who invented their particular design for carrying out scientific experiments in which they were interested. The Helmholtz top and the Busold chromatic top are two well-known instances. Any boy who makes a top of this kind, and experiments with various kinds of discs, can by practical experience find out quite a lot of optical science for himself.

ALL THE WORLD AT WORK TO FILL A PAINT-BOX

All over the world men work hard in order to fill this little girl's paint-box. Here, reading from left to right, we see men collecting ivory for black, insect-cells for crimson lake, resin for gamboge, cochineal for carmine, the indigo plant for indigo, the madder for brown, iron and potassium for Prussian blue, cuttlefish for sepia, earth for sienna, mercury for vermilion, and mineral for ultramarine.

HOW THE PAINT-BOX GOT ITS NAMES

THE WHOLE WORLD OF NATURE IN A PICTURE

EVERY boy and girl has a box of paints, and knows the names of the various colours in it, but probably not many of us know how the paints came to get these curious names in the first place. Their story is an interest ng one, and when we paint a p.cture a whole world of romance centres round the drawing, for the colours have been gathered from all over the world, and the pa nts are made up of the animal, vegetable, and mineral kingdoms.

Cobalt, that beautiful blue colour that is so pleasing to the eye, is made from a poisonous metal which is reddish grey, but which becomes blue when oxidised—that is, when oxygen gas combines with it. The German miners, who found the metal troublesome and dangerous, called it by the German name for goblin, and our name cobalt comes from this word, and really means goblin.

This paint comes out of the earth, but many other paints are made of earth itself. Vandyke brown, for instance, is an earth which the great artist Vandyck used very largely for painting in the backgrounds of his pictures, and because of this the particular kind of brown was called after his name, which in course of time came to be spelt Vandyke.

Burnt sienna is another kind of earth found at Sienna, in Italy, and the first part of its name was given to it because in preparing the earth for the artist it has to be baked. Burnt umber, too, is earth baked in the course of manufacture, and its name, umber, comes from the Italian words *terra d'ombra*, which mean "earth of shadow." Artists use it a great deal for putting in the shades in their pictures, and so the Italians called it "earth of shadow," because it is the earth used for shadowing or shading.

Another earth that we find in the paint-box is yellow ochre. It is a clay that varies in colour from pale yellow to deep orange and even brown, but it is usually l'ght, and the name ochre, which was given to it, is just the Greek word for "pale," with the spelling slightly altered.

Many of our paints are made up from minerals, and one of these is vermilion, whose name comes from the Latin word for a worm, *vermiculus*. Originally, this colour was made from the little cochineal insect, and that is how it got its name; but for a long time past it has been manufactured by chemists, and is really a preparation of mercury, or quicksilver. Prussian blue is another colour that chemists have learnt to make up from iron and potassium and sulphur and other substances all combined together. The first man to make it was a German manufacturer named Diesbach, who lived in Berlin just 200 years ago, and it is this fact that gave the colour its name of Prussian blue. It is sometimes called Berlin blue.

Ultramarine, another blue paint, is a great favourite with artists, because it does not fade or become tarnished however much it may be exposed to the air. It is now made up by the chemists like the other blue paints, but at first it could only be obtained by crushing up a blue mineral called *lapis lazuli*, which is the Latin for azure, or blue, stone. This stone is brought across the seas from various foreign countries, and the name ultramarine comes from two Latin words meaning "beyond the sea." Clever chemists, however, analysed the stone, and are now able to make up the paint without using the mineral at all.

Cyanine is a blue paint made now from chemicals, but originally prepared from cyanine, which is the blue colouring matter of flowers. The word is from the Greek name for dark blue, *kyanos*. Cerulean blue means sky blue, the name being derived from the Latin word for heaven, *cœlum*.

Another famous blue paint, indigo, is not made from minerals, but comes from the indigo plant, which is soaked in water for a long time, and then, when it has decomposed, the indigo is found to have sunk to the bottom of the vessel containing the water. This plant now grows abundantly in America, but it was originally found in India, and the Spaniards called it *indico*, which means Indian. We have simply changed the "c" into a "g."

Gamboge, one of the prettiest of all the yellow paints, also comes from a plant. It is really a resin taken from a tree that grows in Cambodia and other Eastern countries, and the people who first brought it called it after the name of the place where it grew. But gradually the name Cambodia has, by careless speaking, become changed into gamboge. Doctors use it a good deal in making up their medicines.

There are various yellows of lighter or deeper hue which go by the name of chrome—yellow chrome, orange chrome, and red chrome. These are all prepared from the chemical chromium, from which they get

their name. Naples yellow, which has a greenish tint, is made up from the oxides of the two metals lead and antimony, and was originally prepared at Naples, after which city it was called. Another yellow, cadmium, is prepared from the chemical element cadmium, and much of the paint sold as Naples yellow is really cadmium. Strontian yellow is made from the metal strontium, from which it takes its name.

Madder brown is made from the roots of the madder plant, which are washed and baked, and then ground up. During the process the roots appear of a reddish colour, and in some way the earlier manufacturers mixed up in their minds the madder root with the red that is made from the cochineal insect, and called it by the German word for a worm, which is very much like madder. From the root the name gradually came to be used for the whole plant.

Turkey red is also made from the madder root, and as so much of this comes from Turkey, the paint has been called after its country of origin.

Other paints made from the madder plant are known as alizarin crimson, alizarin scarlet, alizarin yellow, and alizarin green. The name alizarin has come to us through the French from the Turkish word *alizari*, which means the madder plant.

Venetian red is a burnt ochre that owes its colour to the oxide of iron in it, and it is obtained principally from Verona, in Italy. Formerly it was much used in making bricks, and many of the old buildings in Venice are built of these bricks. For this reason this particular earth received the name of Venetian red, and though it is now used as a paint by artists all over the world, and not as a brick by the builders of Venice, the original name still clings to it.

Vermilion and madder brown have names connected with insects, although they themselves have nothing to do with the insect world, but there are paints which are actually made from insects. Carmine is one of these. It is prepared from the little cochineal insect, and its name is really the Spanish word for crimson, *carmesin*. This word is the nearest the Spaniards could get to the Arab name for the cochineal insect, *girmiz*.

Another red paint which owes its existence to insects is crimson lake. The word lake is an incorrect spelling of *lac*, a kind of resin that is found on the banyan and other trees in India. The lac is just a mass of small cells made by an insect to protect its eggs, and as the cells are red they are called lac, from an old word meaning to dye.

Sepia comes out of the sea, and is prepared from the dark, inky fluid that the cuttlefish throws out when it is attacked. The ink darkens the water and enables the creature to escape. Sepia is the old Greek name for cuttlefish, and now it is used for one particular variety of this creature.

Another dark colour, ivory black, belongs to the animal world, and is actually a charcoal made by burning pieces of ivory and bone.

Bistre, a brown paint prepared from the soot of wood boiled in water, wears wonderfully well, and sketches of the eighteenth century done in bistre are in an excellent state of preservation. The word bistre is from the German *biester*, meaning dark, gloomy, and is a reference to the colour.

Bitumen, another brown paint made by mixing the mineral pitch bitumen with a drying oil, unlike bistre, does not wear at all well. It cracks with changes in the atmosphere, and pictures in which it is used soon deteriorate.

Chinese white is the white oxide of zinc, and owes its name to the fact that its use was first known in China, from which country our artists obtained it.

Green can, of course, be made up in varying shades by mixing yellow and blue, but in many paint-boxes there are a number of different green paints found ready for use. One of these, malachite green, is made from the green mineral malachite, that is used so much for brooches and other personal ornaments. The name comes from mallow, and the mineral was called after that plant because its colour is so much like that of the mallow leaf. These leaves were once made into an ointment for softening the skin, and as the Greek word for soft was *malakos*, the plant was called after that word, which in course of time has developed into mallow.

The name mauve is also derived from mallow, and was given because of the resemblance of this colour to the mallow blossom.

Another green is viridian, a bright colour, which gets its name from the Latin word for green. Hooker's green, a mixture of Prussian blue and gamboge, is named after the man who first made it.

A number of paints which are prepared from oxide of iron have the name Mars prefixed to their colour, and are called Mars yellow, Mars red, and Mars brown. The word Mars is an old-fashioned name for iron, and was given to that metal

because it is a symbol of the stern and "iron"-natured Mars, the god of war.

From what has been said it will be seen that the whole world is drawn upon to fill up a boy's paint-box, and in the one little box of colours we have the products of the animal, vegetable, and mineral kingdoms. Chemists, gardeners, fishermen, navvies, zoologists, and miners, all have to set to work in order to get the colours with which we paint a picture. In fact, a painting such as that which is reproduced as the frontispiece to this number of the Children's Magazine is one of the most wonderful products of nature and science and art and commerce that we could possibly see. The animal world has contributed some of the browns and reds, the pillar being partly of sepia from the cuttlefish in the sea, the mother's pink dress carmine from the little cochineal insect, and the coat of Jesus crimson lake from the protecting cells of an Indian insect's eggs. The vegetable kingdom has provided some of the yellow, blue, and brown, the garment of the kneeling child being partly of gamboge, a vegetable resin, the blue of the robe worn by Jesus being partly of indigo from the indigo plant, and the ground being partly of madder brown, made from the madder roots. The mineral kingdom has contributed the ultramarine and cobalt blues in the sky, the touches of malachite green in the leaves, the burnt sienna of the tree-trunk, the yellow ochre in the ground, and the chrome in the little girl's yellow dress.

WHY DOES A FIRE BURN BRIGHTLY ON A FROSTY MORNING?

The conviction that a fire does burn more brightly on a frosty morning than it does at any other time is so wide-spread that probably very few people doubt it; and yet, if the truth be told, if all the other conditions in connection with the fire are the same, it will burn just as brightly whether the morning be frosty or not.

If there is any difference, it must be because the dryness of the frost possibly makes a better draught up the chimney, or alters the pressure of the air in such a way as to encourage combustion. But probably in most cases the idea has simply sprung from the fact that a fire on a frosty morning is particularly welcome; in other words, the fire suggests to our mind that it is burning better than usual, and our attention is attracted to it because at that time we are specially glad to see a bright fire. If the morning were warmer, the fire might be burning just as well and we should not notice it. Many things are suggested to our minds in this way by our feelings and sensations, and it does not always follow that the idea we receive is quite a true one. We are trying to convince ourselves that what we wish to be true is really true.

HOW DOES A TREE CARRY SAP TO ITS TOPMOST LEAF?

The sap in a tree is a watery fluid which acts for the tree as our blood acts for us. It circulates through the tree, as blood circulates through the body. The roots of the tree gather the moisture from the earth, and this rises in the form of sap through the fibres of the outer bark, until it reaches to the leaves, having passed through all the branches and twigs. Then it goes down again by a different way, just underneath the bark this time, swelling the bark as it does so.

The sap from the roots goes up the tree through a marvellous structure of tubes or vessels made up of rows of cells. The sap passes through these tubes partly by what is called *capillarity* and partly by what is called *osmosis*. To understand the answer to our question we must explain these two terms.

The word "capillarity" is used to state what happens when very delicate hair-like tubes come into touch with liquids. If such a tube be dipped in water, the water runs into the tube as tea runs into a lump of sugar. In the same way the fluid rises from the roots into the trunk of a tree. The scientist says that it enters the minute tubes by the capillary attraction they exert.

The outer parts of roots are like hairs, and these take up the moisture from the soil, which contains nourishment for the tree. They do so by "osmosis," a name which is given to the physical process by means of which fluids can pass through thin structures. The fluid soaks through, as we say. Being continually absorbed in this way, it pushes up the sap ahead of it, and helps it to run up the tree. The exact way in which the sap does its work is probably not entirely explained by either of these big words and the processes they describe, but that is just one of the great number of things in this world which we can only wonder at. It is well to understand that we cannot understand everything.

A PICTURE IN TAPESTRY OF THE MOST FAMOUS TAPESTRY WORKS IN THE WORLD

A TAPESTRY MADE AT THE FAMOUS GOBELINS WORKS IN PARIS. SHOWING KING LOUIS VISITING THE WORKS ABOUT 250 YEARS AGO

HOW THE TAPESTRIES WERE MADE

All of us are, in a way, weavers of tapestry. Young and old, we stand working at the loom of time, weaving the storied pattern of our lives. We cannot tell exactly what kind of picture we are making out of the hundreds and thousands of things that enter into our existence. Most of us, no doubt, work to some sort of rough design, but we cannot see what the complete effect will be.

The tapestry-maker labours in the same way. His most beautiful pictures are made by him without his seeing them, for he stands behind his loom and not before it. That is to say, he labours on the wrong side of the tapestry, putting in thousands of different coloured threads and weaving them together into some wonderful vision of flowers and trees and figures which he cannot see. He must leave his place and walk round to the front of the loom to see the work he is doing.

At the famous Gobelins, where French tapestry is made, each weaver works three hundred days in the year, and in these three hundred days he produces less than one square yard of tapestry. Eleven square inches is, in fact, a record day's work, and the cost in wages alone of making a yard of tapestry is over £80. It is no wonder, therefore, that good tapestry is very costly. A large modern design is worth £2000 and over, while the masterpieces fetch anything from £75,000.

These prices are not of modern growth. In the days when ancient Britons were still painting themselves with woad, rich men in the Roman Republic were giving £7000 for single pieces of tapestry taken from the temples and palaces of Babylon. Two hundred years later, in the reign of Nero, the same hangings were bought by the Emperor at double the price. Three thousand years before our era, the ancient Egyptians wove tapestries on the same kind of loom now used at the French Government manufactory at the Gobelins in Paris, and many examples of their art have been recovered from ancient tombs.

Races as savage as the Red Indians of America knew how to make tapestry, and all the great civilisations of the world have promoted the art of weaving coloured threads into designs and pictures that were hung round the halls and rooms to keep out the draughts and delight the eyes of the beholders. It is only since wallpapers came into general use in Europe that the tapestry-weavers have sadly diminished in number. Most of their descendants are now employed in carpet-making. But in a few places in Europe the more beautiful and delicate art of weaving picture-hangings is still carried on. In Asia there are many tapestry-makers who produce richly coloured and valuable work.

But what lovers of beautiful and romantic things prize most are the tapestries of the days of chivalry. In the grim fortresses of the Middle Ages the cutting draughts were severely felt, and hangings were used to hide the bare stone walls and cover the doorless entrances to rooms. In country manor-houses, and in the dwellings of town merchants, the use of beautiful tapestry became a necessity rather than a luxury, and churches also kept the tapestry-makers very busy. The woven hangings were the picture-galleries of the people. They were the records of the time, representing the legends of popular saints and the lives of warriors and ladies famous in the stories told around the hearth in winter. On festive occasions in the great towns, the streets were adorned with draperies of gold and silk and pictured hangings. Whenever there was a kingly reception or a solemn religious ceremony, it was sure to be accompanied by a display of the richest tapestries. Unfortunately, very few of these old hangings have come down to us, and so rare are they that they fetch greater prices than the pictures by the most famous old painters. £100,000

would not buy some of the finest pieces of tapestry that are now in existence.

In the old days Englishmen were renowned as tapisers. In 1371 the King of France hung some of his rooms with English tapestry. But the little Flemish town of Arras was for many years the most famous centre of tapestry-making, and the term "arras" is still often used for tapestry. When the Sultan of Turkey captured the son of the Duke of Burgundy, in 1396, he could have obtained a great amount of gold as a ransom, but the Sultan asked only for "some tapestries worked in Arras, representing good old stories." Thus we see how widely and highly esteemed were the pictures woven in the little Flemish town.

A TAPESTRY OF PAUL AND BARNABAS AT LYSTRA, WHERE THEY PREACHED ON THEIR MISSIONARY TOUR

Unhappily, the skilful Flemings were attacked by the French in 1477, and their town was destroyed and annexed to France. Many of the weavers fled to Brussels, and made this city the new centre of tapestry-making. At the present time it is the old tapestries of Arras and Brussels and other Flemish towns which are most sought after, and the finest work is now in the royal palace at Madrid, where it was carried when the Kings of Spain became masters of Belgium, and acquired the splendid tapestries of their new kingdom.

All the greatest artists of Europe were proud to help the Flemings in their work. Some of the finest pictures in England are really cartoons drawn by the great artists of Italy to be woven into picture-hangings for popes, kings, and princes. For instance, at Hampton Court is the famous picture of the "Triumph of Julius Cæsar," and at South Kensington Museum are the splendid cartoons which Raphael drew for the Brussels weavers by command of Pope Leo X. There were ten tapestries illustrating the Acts of the Apostles, for which Raphael received $10,000 for his part of the work, while the master weaver, Peter van Aelst, was given $150,000. The tapestries still hang in the Vatican at Rome. After the death of Leo X. they were pawned for $50,000; six years later some of them were stolen and cut into pieces during the sack of Rome. Some of the pieces were found in Constantinople, and brought back to the Vatican, and then, during the French invasion of Italy under Napoleon, the wonderful hangings were taken to France and exhibited in the Louvre. About a hundred years ago the Pope once more recovered them, and hung them again in the Sistine Chapel.

There are, however, some of these tapestries of Raphael's design hanging still in beautiful old country houses of England. In 1619 some skilful tapestry-makers from Flanders settled at Mortlake on the Thames, and established the art there. Rubens and Vandyke painted designs for them, and

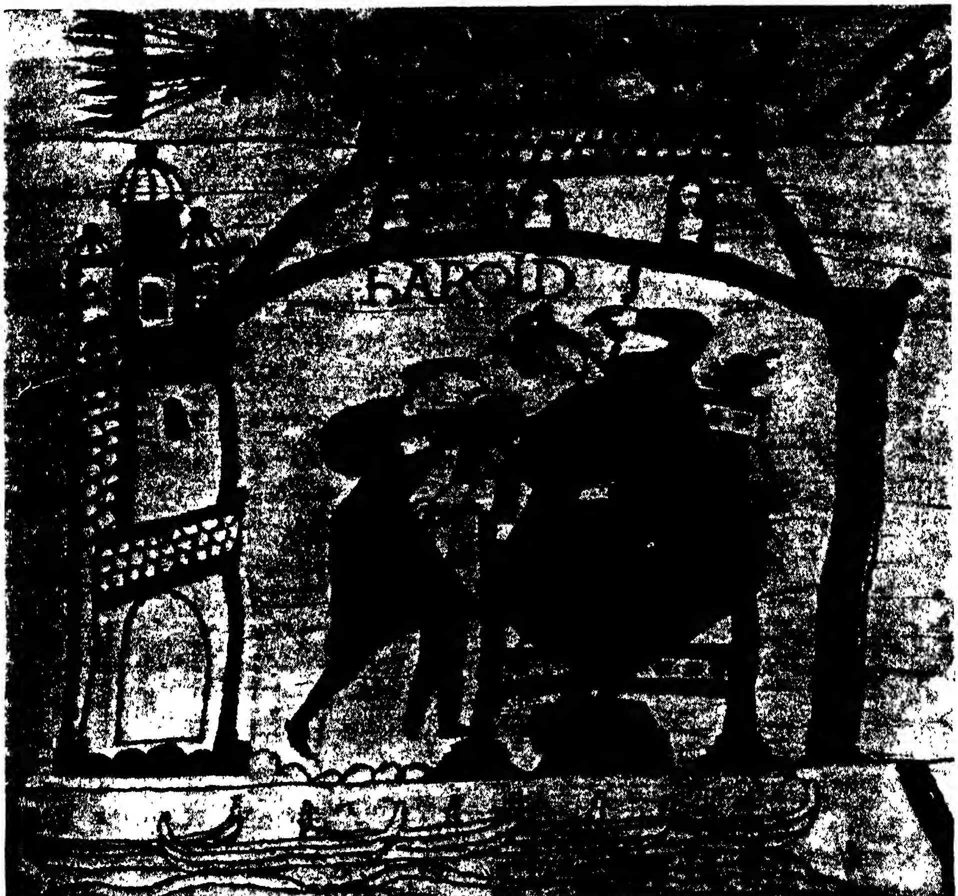
their work became famous throughout the world. Even at the Gobelins in Paris, where some Flemish weavers also settled, no tapestries were woven of such loveliness as those which came from Mortlake. But in the wars and revolutions of the seventeenth century the art of tapestry-making again perished in England, and for nearly two centuries the French weavers in Paris alone kept alive in Europe the highest traditions of the most ancient, as well as the most beautiful, of weaving crafts.

Tapestry is really the most primitive art of weaving. In various remote parts of the world there are still races of savages who make their cloth in much the same way as a tapestry-weaver makes his splendid pictured hangings. The loom consists of two upright pieces of wood, at the top and bottom of which are two wooden rollers. The two rollers—which at first were merely the smooth trunks of young trees—serve to hold the ends of a longish row of threads. These threads form the warp of the material which is to be made. Both the savage weaver and the modern tapestry craftsman proceed in the same way. They pluck each thread apart from the others and insert another thread under it and over the next warp thread. So they make a crosswise weft running through the lengthways warp. At some far distant date in the history of mankind it struck some primitive weaver that he could produce a pretty effect by inserting coloured weft threads into his warp, and thus making designs in colour in the finished fabric. This was the origin of tapestry. The work is still done in the same laborious way as in primitive times. Having stretched his white warp threads on his two rollers, the weaver takes his stand behind his loom, and begins to tie bits of coloured thread to the warp, and weave them into patches of colour. The workers at the Gobelins have fourteen thousand different threads to choose from in making their pictures. They study the cartoon drawn for them by some distinguished painter, and see what colours they need, and then carefully select the tinted threads from the store. Each piece of coloured thread is wound on a peg. To use it, the

A BEAUTIFUL TAPESTRY OF THE BIRTH OF JESUS—FROM A DESIGN BY SIR EDWARD BURNE-JONES

weaver pulls some strings hanging from his loom. These strings are looped round the warp, and by pulling them a part of the warp is brought forward so that the coloured thread can be passed in and between the threads of the warp. In this way a tiny spot of colour is woven into the material. So the weaver goes on building up the picture, thread by thread. At his back is the design he has received from the painter; at his side are his pegs of coloured thread; before him is the wrong side of the tapestry, with many pegs of thread hanging from the places where they were last used; and on the other side of the loom, where he cannot see it, is the picture he is weaving. Yet he seldom makes a serious mistake, for he knows from long experience and training how to get the unseen effects at which he aims. Every now and then he drops his work, and walks in front of the loom to see how he is getting on.

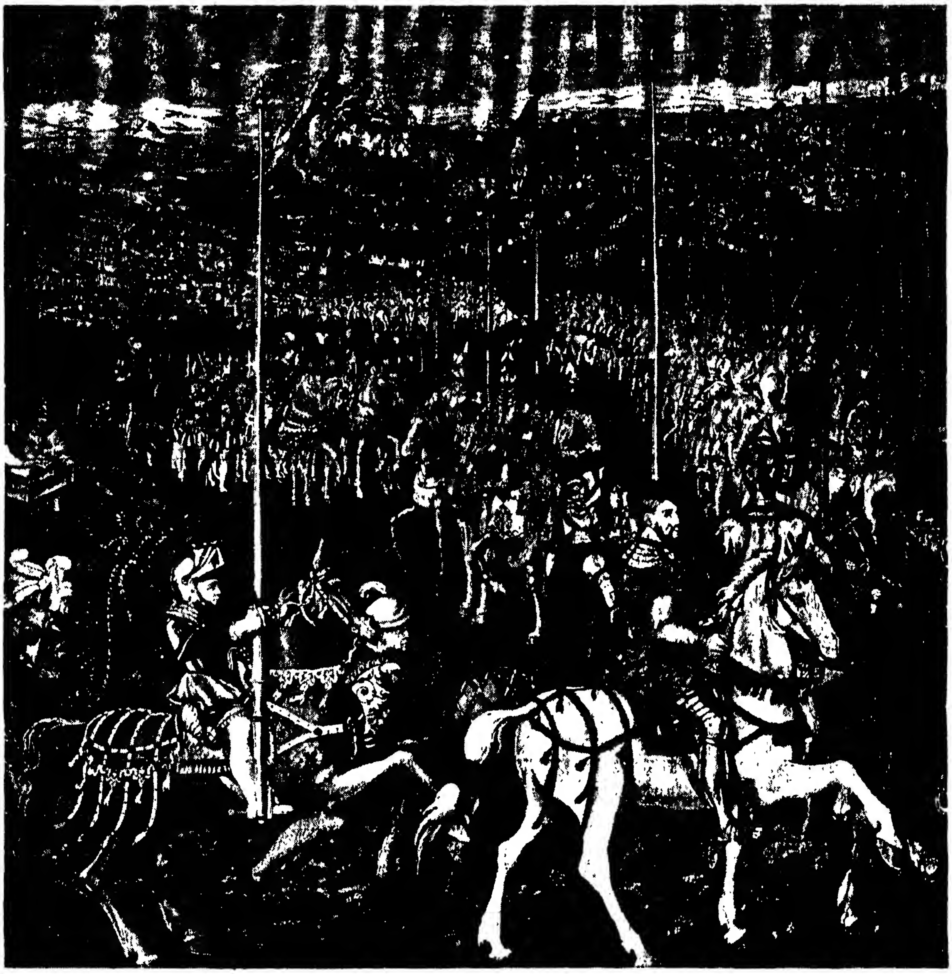
There is an easier way of making tapestry, by means of treadles that move the warp threads, but in the finest work everything has to be done by hand. Some years ago an English poet, William Morris, taught himself to make the best kind of tapestry and then trained some workmen at a little manufactory at Merton. Six of the Merton hangings, after designs by Sir Edward Burne-Jones, were sent to the Paris Exhibition of 1900. The French at once recognised that a formidable rival to their workmen at the Gobelins had arisen, and a grand prize was given to the English tapestry-makers. Tapestry is also being made in Ireland now, and it is hoped that the



THE OLD TAPESTRY PICTURE BY THE WIFE OF WILLIAM THE CONQUEROR—A FRAGMENT OF THE FAMOUS BAYEUX EMBROIDERY, REPRESENTING HAROLD ALARMED BY THE APPEARANCE OF HALLEY'S COMET

revival of the craft may eventually develop into a national industry.

In richness and harmony of colouring modern British work is often considered superior to French work, and if this is so it is due to the genius of William Morris and his helpers, most of whom belonged to a new movement in art distinguished by its splendour of colour and its originality in design. The French work, on the other hand, has tended to grow refined and subtle, so that the bold traditions of the old tapestry-makers have been softened and accommodated to the changing fashions of modern painters. But the French themselves are now aware of this defect, and are aiming at larger and sounder effects. In many countries of Asia the tapestry-makers keep to most ancient schemes of colour, so that some authorities are able to trace in a modern hanging from Persia the traditions handed down from ancient Babylonia. Our oldest European tapestry is connected with the crafts of Constantinople, dating from the days when that city was still a centre of Christian civilisation and the Turks were only a wild clan from Asia. But the Greeks learned their work from Egypt and Babylonia, so that these two countries can claim to be the cradle of the richest and most delicate of all the crafts still left in the world.



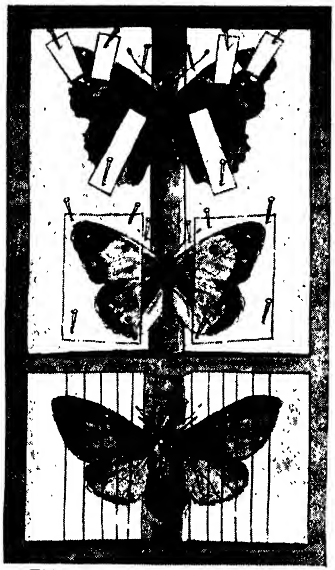
A SPLENDID EXAMPLE OF A GREAT HISTORICAL SCENE RECORDED IN TAPESTRY—KING CHARLES V. OF SPAIN REVIEWING HIS ARMY AFTER THE CONQUEST OF TUNIS

HOW TO MOUNT BUTTERFLIES

A VISIT to the entomological collection of any first-class museum will show what a well-set specimen should be. There are, of course, various methods of going to work, all of which are good. The first thing is to make one or more setting boards, and these will vary in size according to the size of the specimens. For most of the Noctuas, for instance, the board should be a foot in length and three inches in width.

Down the centre of the board make a groove. For the ordinary-sized Noctuas the depth should be half an inch, and the width three-eighths. At the bottom of the groove a thin strip of cork about an eighth of an inch in thickness must be glued, and the board planed down slightly on each side of the groove till a section has the appearance shown in the first picture.

INSERTING THE CORK


THREE WAYS OF MOUNTING

In making these boards the most important points to remember are that the grooves should be wide enough to take the body of the insect comfortably, and of such a depth as to leave a small space between the board and the wings when the body is pinned down to the cork. The actual degree of slope on each side of the groove is not important.

The next thing is to pin down the insects, and this is the most difficult part of setting. The pins are sold usually by the ounce, and black ones have the best appearance.

To begin with, three sizes would be sufficient, the shortest being for small butterflies and moths, the longest for the very large specimens, like swallow-tails and hawk-moths, and the middle size for the rest.

In putting the pin through the body of the insect, the head of the pin should slope a little forward towards the head of the insect, and about three-eighths of an inch should project beneath the body. Be very careful that the upper part of the pin does not lean to either side. Now pin the specimen down to the board, with the body resting in the groove, and a slight space between the wings and the board.

The delicate operation of arranging the wings comes next, and is done by means of cotton and a fine needle. The body is in position in the groove, and the creature's wings are closed together. Using a pin stuck in the board as a pivot, and tying to this a length of cotton, we insert the cotton between the wings and gently draw the wings down on one side, arranging them with the needle while the cotton is still over them. When the specimen is dry, of course, all supports but the body pins are removed.

Now we have to fix the wings, and there are various methods of doing this, as shown in the second picture. We may use small tabs of stiff card, pinning them down as shown, or we may use a piece of glazed tracing cloth or stout greaseproof paper, covering the whole of the wings on each side, as indicated in the second specimen, or we can fix the wings down with strands of cotton passed round the board lengthwise, and fixed in nicks at each end. For the beginner, probably the first method will prove the easiest, as it enables the wings to be arranged in instalments. When one side of the butterfly is arranged thus, the other side must be tackled, the chief difficulty being that of having the wings on both sides exactly at one level. To keep the bodies straight, pins should be stuck into the groove of the board underneath the lower end of the body to support it. The antennæ and legs must also be carefully arranged, and, if necessary, may be kept in position by pins stuck into the board slantingwise, and pressing upon the antennæ and legs.

The specimens should be laid aside to dry in a shady though warm place, free from dust and secure from the attacks of mice or cockroaches. Small specimens will dry quickly, but the larger ones may take three or four weeks. To know whether a specimen is ready for placing in the collecting cabinet, touch the abdomen with a needle, and if the skin is stiff and immovable the drying is completed.

In the cabinet the specimens are liable to suffer from two scourges—mould and mites. To prevent mould an absolutely dry situation must be found and the specimens examined frequently, and to guard against mites a little napthaline should be placed in the box.

What You Should Know

ABOUT THE LINOTYPE

ONE summer's day, as I was leaving a great club in London, a group of men were gathered round the little printing machine that clicks out the news hour by hour, and I shall never forget the moment when the invisible power that works these wonderful machines printed these six words before our eyes—LORD KITCHENER AND HIS STAFF DROWNED. It seemed impossible that if such a momentous thing as that had happened, stirring the emotion of every freedom-loving man in Europe, cold type should register it so quietly there. Surely the type that printed words like these should leap from its place, and not lie there unmoved, mocking men whose hearts could hardly bear the thing it said.

That is what we feel about type; it is so cold and still, yet it stirs our blood and sets us all on fire. Somebody has said that if a man gets a telegram saying, "Our son is dead," he is moved to sympathy; but if the telegram says, instead, "Your son is dead," his heart may break. And yet there is only the little difference of a letter. All that the eye sees is a little more ink on the paper, yet it may mean more than we can imagine. Who can measure the effect of words like those of which Shakespeare said, "Here are a few of the unpleasantest words that ever blotted paper"?

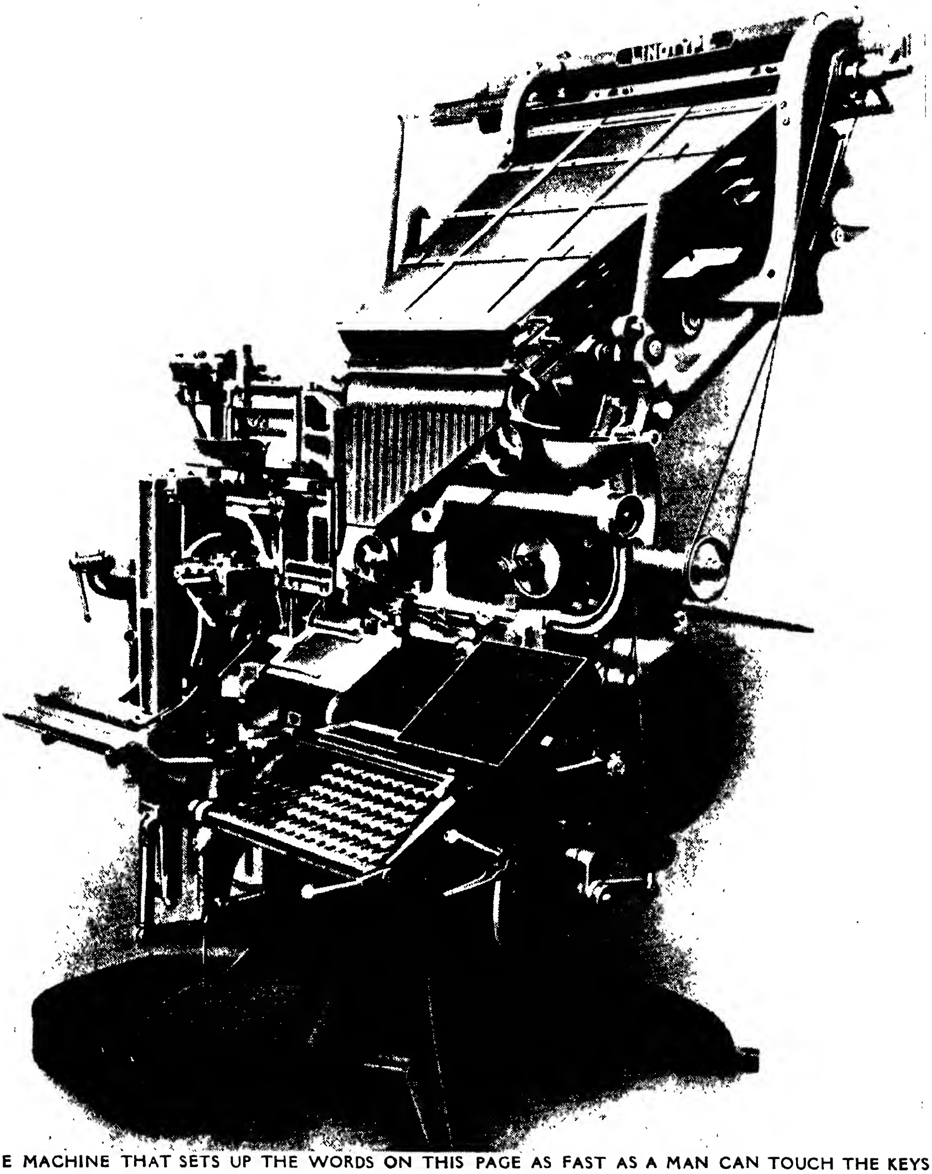
Such power have printed words over the mind that they may change a nation in a single day as truly as an earthquake. They can move a nation to laughter, or to scorn, or to burning shame; and in these emotions roused by words nations will act and change the course of human history. And so we see at once that the man who gave the world the printed word gave it a power that men could never have dreamed of before then. In those early days of the world a man had no way of spreading his thoughts except by speaking them, or writing them with great labour. The few books that were produced at all were written by hand, mostly in monasteries by monks who toiled from morning till night, loving their work and making their pages beautiful to see. A book was then worth fully its weight in gold. Men would sell land and houses to buy books.

The world has moved a long way forward since then, and it is sad in these days to remember that two great steps in this upward march were taken by the nation that has since flung civilisation to the winds and turned its face towards barbarism.

It was Gutenberg, a German in the early days of the Hohenzollerns, who laid the foundations of modern printing five hundred years ago; and it was Mergenthaler, a man of Gutenberg's race, who took another step forward, thirty years ago, and gave mankind the linotype. We say he gave it to mankind, for surely this was a gift to all our race. When Gutenberg was a boy, artists drew their pictures by cutting them in wood, and the wood blocks were inked over and proofs were pulled from them. Then whole pages of letters and words were cut out in one piece of wood, and it was Gutenberg who first of all hit on the idea of making separate letters.

He saw that if you had several alphabets cut out you could arrange letters as you pleased, and out of that idea grew the modern way of setting up words in metal type. Still the work was done by hand, and the newspapers our fathers read were set up letter by letter. A man would stand at a case with thousands of letters in dozens of little boxes, and before a newspaper could be printed scores of men must stand at these boxes, picking up perhaps a million pieces of type or more, all so precious that they must be carefully collected and put back in their little boxes.

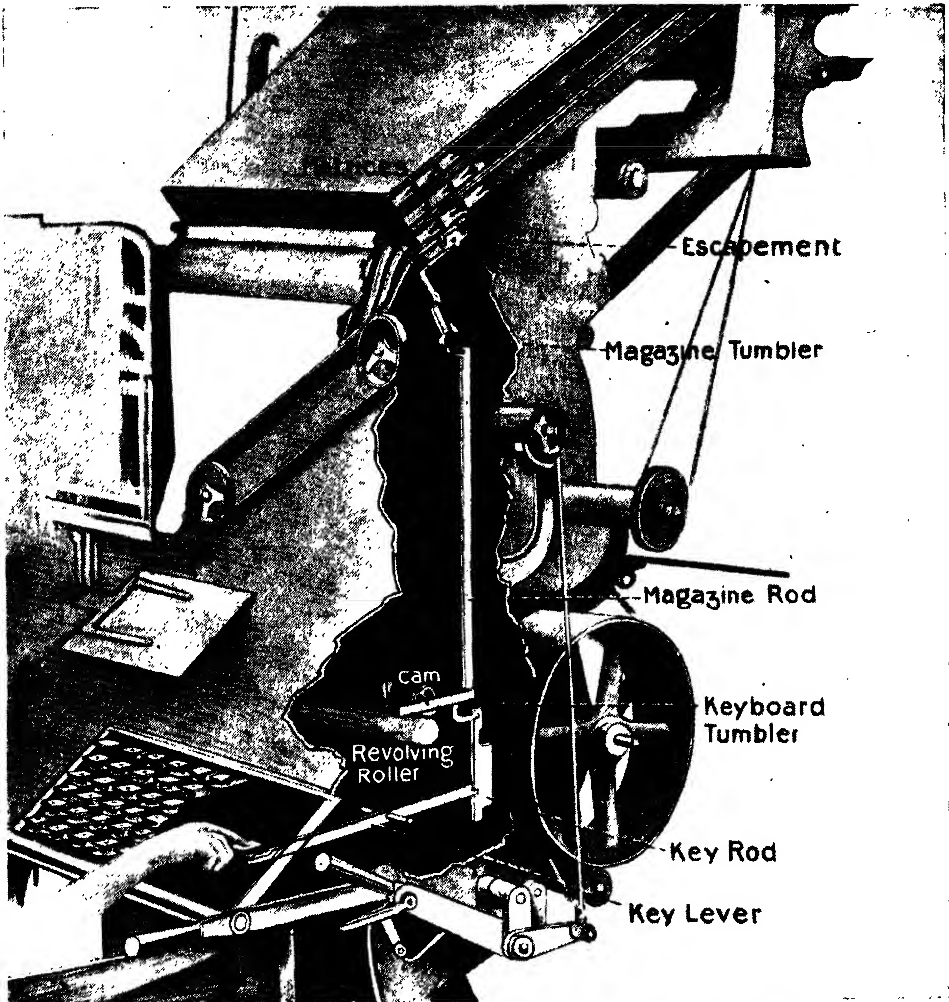
For hundreds of years after Gutenberg this was done, and there was no other way of printing until thirty or forty years ago. It was then that the clever brain of Mergenthaler worked



THE MACHINE THAT SETS UP THE WORDS ON THIS PAGE AS FAST AS A MAN CAN TOUCH THE KEYS

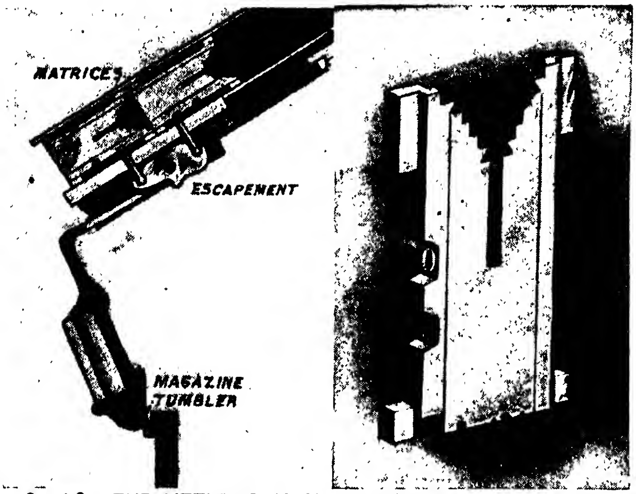
out the idea of the linotype, the machine at which a man can sit and think, "What a beautiful thing a rose is!" and set up the words in a solid line of type even as he thinks them. It is a machine that almost thinks; it is in itself one of the great mechanical wonders of the world; but we value it most of all, not for its own sake, but for the work it does, for it makes possible quick and cheap printing, and of cheap and quick printing we can say that without doubt it does more to shape and rule the world we live in than anything else on earth.

Here we see the linotype and the way it works; most of these pages are set up by it.

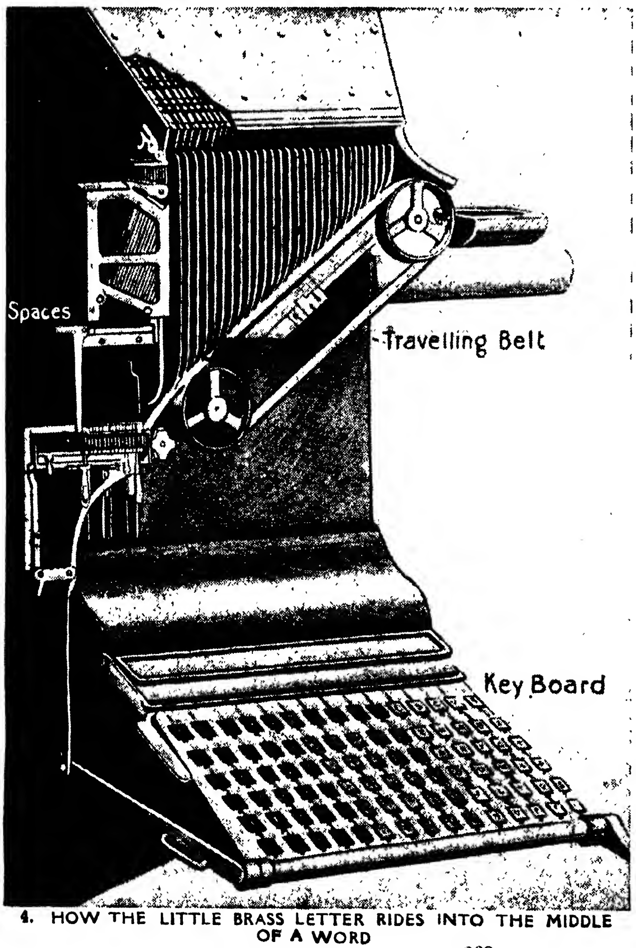


1. HOW THE LETTERS OF THE LINOTYPE FALL INTO THEIR PLACES

1. The linotype, so called because it sets up a line of type, is shown complete on the opposite page. In the case at the top are about 1500 brass moulds with the shapes of nearly a hundred letters cut in them, and by many wonderful processes a mould is brought to the place where it is wanted, other letters fall by its side, and molten metal comes pouring up to them. The metal cools and sets hard, and, lo! we have a line of type. On this page we see the operator pressing down a letter on the keyboard As the key goes down the other end of the key-lever comes up, raising the key-rod with it. The raising of the key-rod removes the support of the horizontal bar on which the cam rests, and the cam then falls upon the revolving roller. As the cam goes round, its uneven rise-and-fall action causes the magazine-rod to rise and fall also, and the result of this is that what is called the magazine-tumbler is made to rock. That is exactly what is wanted, for this tumbler, by working the escapement, controls the matrices, the brass moulds with the letters cut in them, and one of these must run down to a little place at the operator's left hand. The mechanism we have followed runs separately from every letter on the keyboard to a box of letters in the magazine at the top, and the pressing down of the key, and all the movements that follow, are for the purpose of bringing one of these letters down.



2 and 3. THE LITTLE BRASS MOULD AND HOW IT ESCAPES



4. HOW THE LITTLE BRASS LETTER RIDES INTO THE MIDDLE OF A WORD

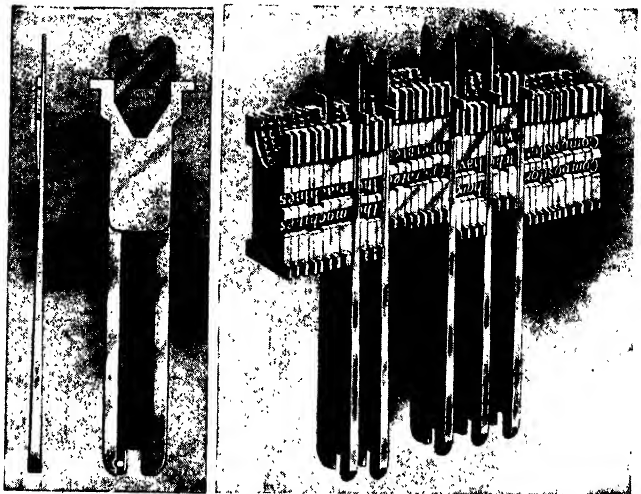
2 and **3.** The little brass matrices with the letters cut in them are held in check by a tiny brake called the escapement, and the rocking of the tumbler releases this, so that it lets go the first matrix and holds back the second. The little brass mould, being free, runs to the place where it is wanted, as we shall see in the picture below. Side by side with the escapement we see here the mould itself, a curiously-shaped little thing with teeth like a double set of steps, which serve a most important purpose. But most of all we must notice the letter cut in its side. In the matrix shown here there are two letter o's, one in Roman type and the other in italic, so that either can be used by a clever movement on the part of the operator.

4. On being released the matrix runs forward, out of the box in which it has been imprisoned, down the groove in front of the machine. Here we notice a very interesting and ingenious device. The letter has to reach its proper place at the proper time; it must neither be too early nor too late. Now, if some letters are farther away from their destination than others there will be great confusion, because they will arrive in the wrong order, and the spelling will be worse than that of Robert Louis Stevenson, who is said to have never been quite sure how to spell. The travelling belt seen in this picture, running down from right to left across the front of the machine, solves the whole of this problem, and it is so cleverly arranged that, although there are ninety different letters and figures on this keyboard, all coming from different places, every one of them takes exactly the same time on its journey. It goes to what is called the assembly-box at the end of the belt, the

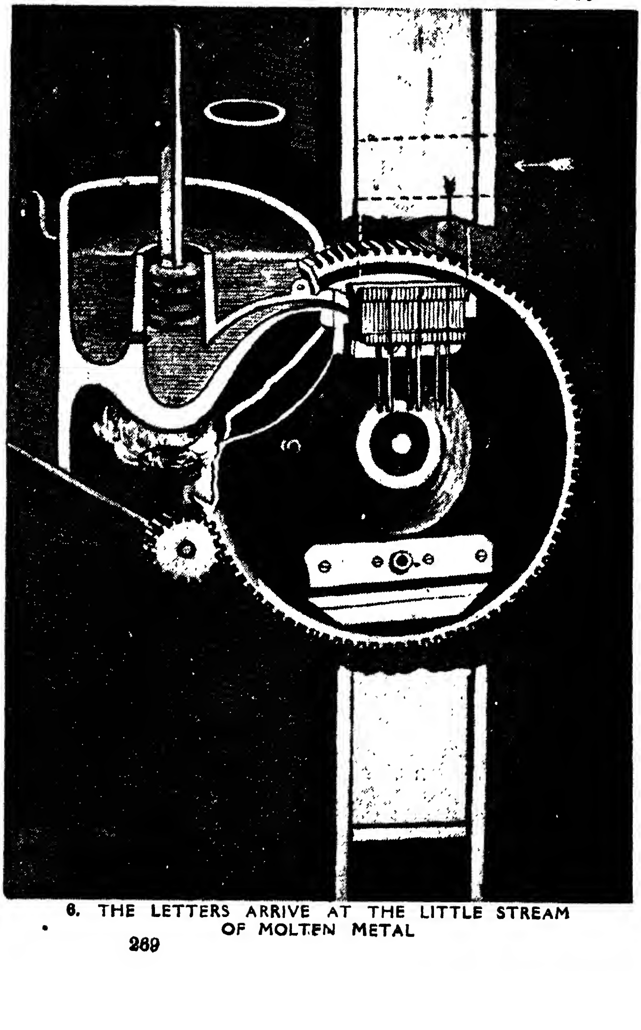
belt dropping it neatly into its proper place. In this picture the assembly-box is nearly full of letters, and the letter just running down may fill the line. If it does not quite fill the line the space bands will put things right.

5. We shall see at once, the moment we think of it, that the spacing out of the words must have been a bothering thing to the inventor of the linotype. Remember that the line is to become a solid piece of metal, so that it cannot be interfered with once it is made, except by breaking it up and making it over again. After one word the operator touches a special key for spaces, and down slips one of these curious steel wedges, much longer than the matrix. Now come down more letters, and at the end of another word comes another wedge. At last the line is finished. But suppose it is a little short? That will not do, and it will certainly not do to leave the operator to put things right with his fingers. What actually does happen is that these steel wedges, thin at one end and thick at the other, move as is needed to make the line the proper length by adjusting the spaces equally between the words. You would have thought yourself a clever inventor if you had thought that out; and it is only one of a hundred clever things in the linotype. We see here a line of matrices spaced out, and if you turn this page upside down you will be able to read the words in the moulds.

6. At the back of this wonderful machine that we see, and in the very heart of it, are metal and fire. A gas-jet beneath a metal-pot is burning all the time, keeping the metal molten. In front of the metal-pot is what is called the mould-wheel, and at the top of this wheel is a long thin slot. The line of



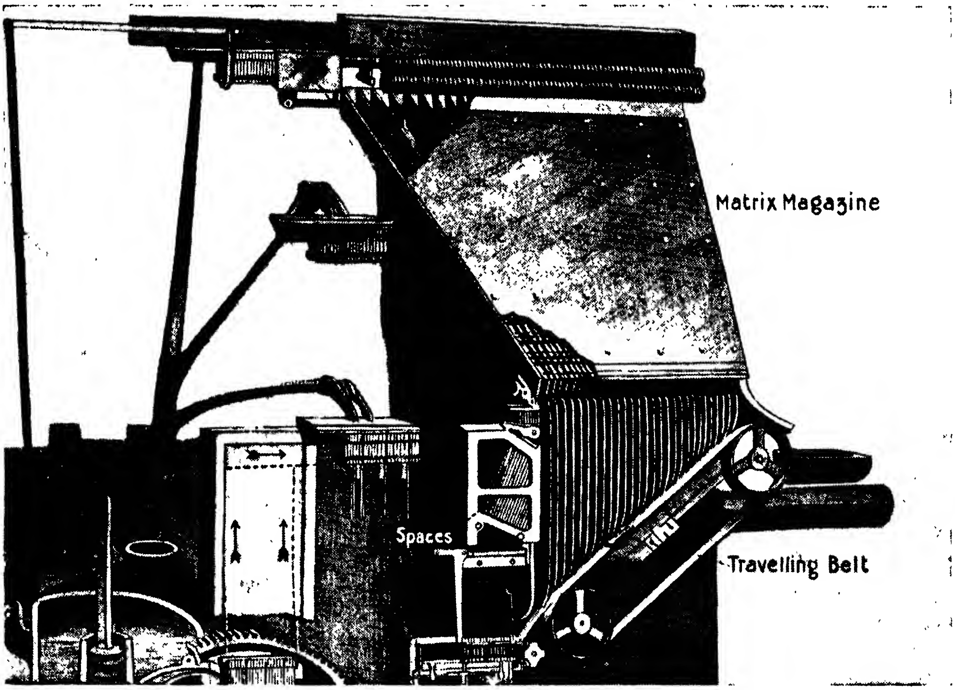
5. THE LITTLE WEDGE THAT SPACES OUT THE WORDS



6. THE LETTERS ARRIVE AT THE LITTLE STREAM OF MOLTEN METAL

letters that we have seen fall into their places are raised by the movement of a lever so as to follow the direction of the arrows in this picture until they rest in front of the slot in the wheel. The cut-out letters are facing the slot, pressed tight into it. Now you will guess what happens. Coming down into the pot is a plunger, and as the line of matrices rests against the slot the plunger descends and forces down the molten metal, which shoots up the narrow curved passage that leads to the slot. The molten metal is now in contact with the little brass moulds, and there it quickly forms into a solid piece. The end of all these operations has now been reached, for this solid piece of metal has upon the face of it the raised-up letters that are cut out in the moulds.

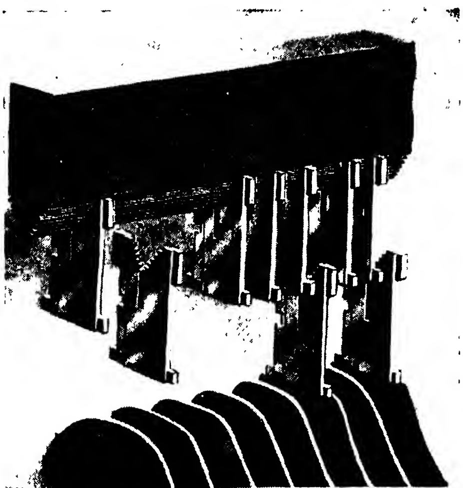
the arrows until they reach the place where the elevator comes down to them. The elevator picks them up and carries them to the distributor-bar at the top, in the way the artist has suggested here. There is only one arm, of course, in the linotype; the extra arms are shown here to explain the movement. The complex mechanism of such a machine as the linotype can hardly be realised. Nothing is simple. It would seem simple enough, perhaps, to lift away this line of words now that it is done with, but what is to happen to the long wedges that make the spaces? They do not go the same way home as the brass moulds, and arrangements must now be made for two separate journeys. What happens is that the space-bands are not gripped by the elevator, which takes off



7. HOW THE LITTLE BRASS MOULDS GO HOME AGAIN

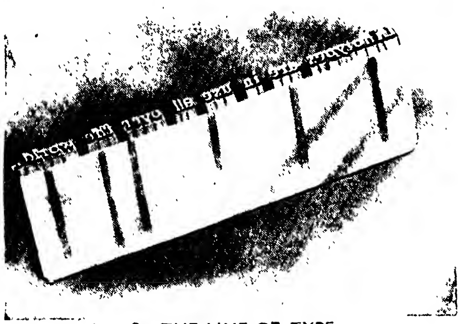
7. Now the brass letters have done their work, and must go home, ready to be used again Here we see them still in their place at the slot in the mould-wheel, and we see in this picture a curious suggestion of what happens. Above the mould-wheel rises a strange mechanical arm, which pounces down, picks up the matrices, and takes them to the top of the machine. They rise first of all in the direction of

only the letters, and another complicated piece of mechanism, not shown in these pictures, takes away the space-bands and drops them in the space-box on the right. The matrices are carried by the elevator to the distributor-bar, which runs along the top of the machine. It is now that we come to the part played by the teeth in the top of the small brass moulds. We shall see how they guide the moulds back home again.



8. HOW THE BRASS MOULDS FIND THEIR WAY

8. The bottom of the distributor-bar is cut into ribs, as shown here, and the ribs are of varying length and arranged in varying ways. We can easily understand what happens now, for the little matrices, hung on to the distributor-bar by the elevator, are pushed along until the teeth fit exactly into the ribs and spaces of the bar. Then they fall, and when they fall they are home again, each in its proper place. The moulds are moved forward by the long revolving screws on each side of the bar, as shown in the last picture.

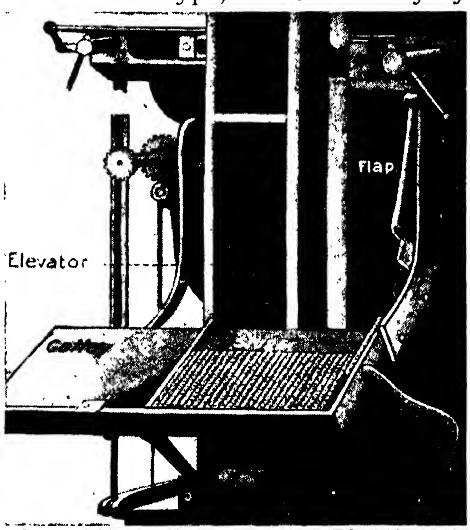


9. THE LINE OF TYPE

9. This is the line of solid type as it leaves the mould-wheel. In order that it shall print the proper way it is cast backwards, but the words can be easily read.

10. We have seen the line of type as it is made, but we have missed the knives which cut it and trim it clean as it is carried from the mould. Passing between two parallel knives, it is trimmed to the exact length and width required. It is then lifted mechanically to a position from which it slides into its place next to the line which was cast before it. We see the new line slipping into place in this picture, and so the lines—or "slugs," as the operators call them—come into the galley-box arranged in column form, where they are carried to the galley-press, on which they are proofed for correcting before they are made into pages and sent out into the world.

We have now, in not many minutes, tried to understand the marvellous machine on which one of the cleverest men who ever lived spent years of his life, but we should have to live with the linotype, or sit at it day by



10. THE LINES OF TYPE GROW INTO COLUMNS

day, as the good and patient men who set up this magazine do, if we would understand it all. Even in this mechanical wonder there is no finality, but the wonder grows and grows; and now it is possible to have a linotype with four magazines of letters at the top instead of only one, and with six complete alphabets in each magazine, so that a single machine may carry twenty-four alphabetical sets in different sorts of type, with a total of 700 separate characters all worked from one keyboard. "A drop of ink makes millions think," said Lord Byron; and this machine that makes the type for miles of paper and rivers of ink makes us think too. It is as good as a steel brain.

HOW WE GOT OUR COMMON SIGNS

THE REASON FOR THINGS THAT WE WRITE EVERY DAY

THERE are all kinds of familiar signs and symbols which we are constantly seeing in books and newspapers, and the meanings of which we know quite well, but how they came to stand for these meanings very few people are able to say.

THE BEGINNING OF OUR MONEY SIGNS

Take, for instance, the letters £ s. d. We all know that these stand for pounds, shillings, and pence, but we ought also to know why these particular letters are used. They are the initials of the Latin words for pounds, shillings, and pence—libræ, solidi, and denarii; the corresponding symbol for farthing is q, from the Latin word quadrano, a fourth part. The sign lb. for pounds of weight is made up of the first and third letters of the Latin word libræ.

Probably most readers of this book know that $ stands for dollar or dollars, and we may have often wondered how this curious sign came to be invented, and why it represents dollars. Long ago, before the United States was an independent country, the principal coin that circulated in many of the southern provinces of North America was the Spanish dollar. This coin was worth eight reals, and a real, which really means a royal, was, of course, another Spanish coin.

As the dollars were each worth eight reals, they came to be known as pieces of eight. We remember how Robinson Crusoe found some pieces of eight in a locker on the wrecked ship. In the old days the sign for dollars in the account books was a figure 8, with a slanting stroke on each side of it, thus /8/. After a time, so as to take up less space, and to save confusion with the ordinary 8, the strokes were drawn through the 8, and our familiar dollar sign ($) is merely the modern form of the old cancelled figure 8.

SIGNS FOR WEIGHTS AND MEASURES

In the sign cwt. for hundredweight, and dwt. for pennyweight, the wt. is, of course, an abbreviation of weight—the first and last letters—and the c is the Latin numeral for a hundred, while d is the d of denarius, a penny. The hundredweight used to consist of only a hundred pounds avoirdupois, and it does still for some articles. The pennyweight was originally equal to the weight of an old Norman penny, and in this way received its name.

We write oz. for ounce, but, of course, there is no z in the word ounce. Where, then, can it have come from? In the Middle Ages there was a sign (ʒ) which was placed at the end of a shortened word to show that it had been abbreviated, and so, when the first letter of ounce was placed instead of the whole word, a ʒ was placed after the o to show that it was an abbreviation. Later this sign became transformed into the letter z, and now we write oz. instead of the word.

A similar explanation may be given of the sign viz., for namely. It is really the first two letters of the Latin word *videlicet*, which means namely, and a z to show that it is shortened. As in ounce, the z was originally the sign ʒ.

SHORT FORMS FOR SOME WORDS

Etc. is short for *et cetera*, which means and the others. Sometimes it is written &c., the c being the initial letter of *cetera*, and the & representing and. This sign is called an ampersand, a word that has come from the four words "*and per se, and*," which means "and by itself = and." The Latin word *et* was shortened into &, in which the cross-piece only of the *t*, in the form of a scroll, appeared, and this developed into the & that we now use.

There are other signs which have gradually come to their present form from a shortened way of writing them. In an account we see that so many articles are charged @ a certain sum each. The @ is really a shortened way of writing *ad*, the Latin word for to or at. Account itself is frequently written $^a/_c$, but this is really incorrect, for the sign stands for account current, and means an account that is running on for a month or more, according to agreement. The *a* represents account, and the *c* stands for current; the stroke is merely to separate the two initials.

We often write shilling or shillings with a slanting stroke, thus 5/-. This is thought to have been originally an old-fashioned *s* (ſ), something like an *f*, but gradually it was written more and more carelessly, until at last it became a mere stroke. We still use the stroke to represent shillings, although we have long since ceased to use the old-fashioned s. When there are no pence we put a little dash, because a dash is written much more quickly than a nought.

WHERE THE STOPS COME FROM

The signs we use for punctuation, the period, or full stop, the comma, colon, and so on, are not so ancient as we might think. Aristophanes—the Greek grammarian of Alexandria, not the famous Athenian who wrote plays—is said to have been the first to use full stops, but the other punctuation marks, the comma, semicolon, and colon,

were invented by Aldo Manuce, also called Aldus Manutius, a printer who lived at Venice in the fifteenth and sixteenth centuries. Our sign for a semicolon was the Greeks' mark of interrogation.

The present question mark (?) and the exclamation mark (!) have a similar and an interesting origin. The ! represents the Latin exclamation *Io*, which was used to signify a cry of joy. When the Latin writers wished to signify joy they wrote this word, then, so that it might not be read as a part of the verse or line, they wrote the letters one above the other, thus $\frac{I}{o}$, and this, in rapid writing, soon developed into !. The ? came similarly from the first and last letters of the Latin word *questio*, meaning question, written one above the other in the same way $\frac{Q}{o}$. The Q written quickly became a ? and the o became a point.

SIGNS TO GUIDE US IN BOOKS

We very often see little signs in books directing our attention to footnotes at the bottom of the page. The most familiar of these is the asterisk (*), and it probably came into use first in handwriting, because a rough star is the most natural sign to draw when seeking to attract attention to a certain part of a manuscript.

Another sign used to remind readers of a footnote is the dagger (†), or obelisk, as it is called. This, which is in the form of a cross, was originally used in Roman Catholic service books as a reminder to the priest to make the sign of the cross. Later it was used in books, like those of classical authors, to mark passages of doubtful genuineness, and then it came into use for directing attention to footnotes. We often see a book spoken of as 4to, or 8vo, or 12mo, or 16mo. These signs stand for the Latin words *quarto*, *octavo*, *duodecimo*, *decimosexto*, and so on, meaning for the fourth, eighth, twelfth, sixteenth time. The meaning is that the size of the page of the book depends upon the number of times a large sheet of paper has been folded. If folded eight times, the book is 8vo, if twelve times, 12mo, and so on. Sometimes the word royal, or imperial, or another word, follows the 8vo. These are the names given to large sheets of paper of different sizes.

THE SIGNS USED IN ARITHMETIC

The signs that we use in arithmetic are known to all, but their origin is not so familiar. The sign =, meaning equal to, was first used by Robert Recorde, of All Souls' College, Oxford, in 1531. To save himself the trouble of writing the words "equal to" again and again, he drew two little lines equal to one another.

The sign for addition (+) is really a carelessly made *p*, from plus, the Latin word for more. The —, for subtraction, also comes from a shortened Latin word, *minus*, meaning less than, which was written *m n s*, with a horizontal stroke on top to show that it had been shortened. Then the letters were omitted, and the stroke only written.

The multiplication sign (×) was invented early in the seventeenth century by Oughtred Etonensis, the most famous mathematician then in Europe. It was simply the + sign turned round, multiplication being a short way of doing addition. In division the Hindus used to put the dividend above the divisor with a horizontal line between, and from this plan the Arabians developed the sign ÷, placing it between the dividend and divisor. The sign % for per cent. has developed from ÷, once used for per cent. as well as for division.

The radical sign (√), meaning that the square root of a number is to be taken, is really the first letter (*r*) of the Latin word *radix*, meaning root. The · used in decimal fractions was invented by John Napier, the man who also invented logarithms. The *n* used in algebra to signify any indefinite number is the initial letter of the Latin word *numerus*, meaning a number.

LETTERS STANDING FOR WORDS

The real meaning of two or three other letters and abbreviations may be given. The X in Xmas and Xianity, which stands for the syllable Christ, is meant to represent the Greek letter *chi*, *x*, the first letter in the Greek name Christ. The letter R in the royal monogram G.R., E.R., V.R., and so on, stands for the Latin word *Rex or Regina*, which mean king or queen.

In the Church of England Catechism when the question is asked "What is your name?" the answer given is M or N. The M has really come from NN, meaning names, and the N stands for name, the meaning being that the one responding is to give his names if he has more than one, or his name if he has only one. By an error of the early printers the NN became an M. With regard to the original use of two N's to represent the plural names, we still follow this practice in writing LL.D. for doctor of laws.

In the Marriage Service the initials used where the man and woman give their names are M and N. It used to be suggested that M stood for Mary, the patron saint of girls, and N for Nicholas, the patron saint of boys, but there is nothing in that.

Another explanation is that M stands for *maritus*, the Latin word for husband, and the N for *nupta*, the Latin for bride. But as in ancient Prayer-books there is no M, the initials being N and N, it is more likely that the N stands for *nomen*, or name, and that M was put in the place of the first N by a mistake, which became the common usage.

THE SIGNS USED FOR THE STARS

We all know the names of the constellations in the zodiac, that belt of the heavens which includes all the apparent positions of the sun as known to the ancients. It is divided into twelve equal parts, called the signs of the zodiac—the Ram, Bull, Twins, Crab, Lion, Virgin, Scales, Scorpion, Archer, Goat, Water-Carrier, and Fishes.

In a circular chart of the zodiac the different creatures and persons named are usually represented by regular pictures; but there are also a number of curious signs which stand for the constellations, and in books, especially those on astronomy, these marks or symbols are often met with. The sign for the ram is ♈, which is a rough representation of the face and horns of a ram; the bull is represented by ♉, which is also intended to be the head and horns of a bull. Two upright strokes joined at the top and bottom (♊) stand for the twins, being of the same size and shape. The crab (♋), the virgin (♍), and the goat (♑) were no doubt all originally pictures of what they represent, but they have been gradually changed beyond resemblance in the course of many hundreds of years. The sign for the lion (♌) is believed to represent the tail of an angry lion, and it is supposed that the name refers to the Nemæan lion slain by Hercules. The scales (♎) is a rough representation of a balance. The symbol for the scorpion is like a letter ♏, and is thought to have originated as a picture of the scorpion, the end of the m being the scorpion's tail. The archer is naturally represented by an arrow (♐), and the water-carrier by (♒), which is intended to be a picture of the ripples on water. The fishes (♓) is meant to be two fishes joined together.

SIGNS FOR THE SUN AND THE PLANETS

There are other regular symbols used in astronomy. The sun is shown by ☉, the dot being the sun and the circle the heavens around it. The earth is represented by ⊕, the circle being the earth and the two lines the polar and equatorial diameters. The symbols for the moon—● (new), ☽ (first quarter), ○ (full), and ☾ (last quarter)—are obviously pictures of this satellite. The planet Mercury is shown as ☿, which is the ancient herald's wand carried by the god Mercury. Venus is represented by ♀, which is just a picture of her hand-mirror, while ♂ for Mars is the arrow and shield of the god of war, after whom the constellation is named. Jupiter's symbol (♃) is really the Greek letter Z, the initial for Zeus, the Greek name of the god Jupiter. Saturn is represented by ♄, which is a picture of a sickle. Neptune's sign (♆) is the trident, which the god is usually seen holding. Vesta is represented by ⚶, which is a picture of the sacred fire on the altar, that used to be tended by the vestal virgins. For Ceres, named after the goddess of agriculture, we have ⚳, which is a sickle.

ROMAN NUMERALS

The origin of the Roman numerals is interesting. I, II, III explain themselves, and also IIII, used on clocks and watches. Five, V, is supposed to have originated from the early practice of holding up the hand to represent five, with the thumb and forefinger extended. Ten, X, is two fives placed one on the top of the other $\genfrac{}{}{0pt}{}{\text{V}}{\Lambda}$. A hundred, C, is the first letter of *centum*, the Latin word for a hundred, and L, for fifty, is the bottom half of C, which was originally written thus [. The Latin word for a thousand is *mille*, and the initial M stands for the number. An old way of forming the M was this CD, and half of this, D, was used to represent half a thousand.

We may often see in books and encyclopædias, and even in newspapers, some such collection of words and figures as this—15 & 16 Vict., c. 76, s. 128. This is a reference to a particular section of a certain law passed in the session of Parliament which was held during the fifteenth and sixteenth years of Queen Victoria's reign. The c stands for the Latin word caput, which means head, and from that word we have obtained, through the French, our English word chapter, which is what caput means here. The s stands for section. The original copy of a law contains no sections, these only appearing in the printed copies, and in neither are there any divisions into chapters.

The reason for this is that all the Acts passed in one session of Parliament are regarded as one law, each particular Act passed being regarded as one chapter of the law passed in that session. 21 Jac. I., c. 16, s. 3 means section three of chapter sixteen of the law passed in the Parliament held in the 21st year of James the First's reign. Jac. is short for Jacobus, the Latin word for James. Car. means Carolus, the Latin for Charles.

HOW THINGS ARE DONE

HOW CUT GRAPES ARE KEPT FRESH

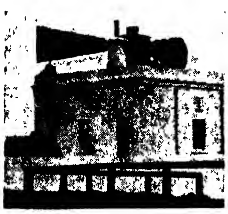
When grapes have been cut from the vine they are liable to shrink a little, and take on a slightly withered appearance, if allowed to lie about, or even if they are merely suspended. There is, however, a simple method of preventing even the first freshness of a bunch of grapes from passing away after it has been cut, and this is by placing the stalk in water, in the manner indicated in the picture. Of course, a rather longer stalk than usual has to be cut, and it is essential that the bunch itself should hang away from the bottle so that the air can play freely all round it.

HOW GARDENERS KNOW WHICH POTS TO WATER

When a gardener has a large number of flower-pots to look after, it is necessary that he should have some quick way of knowing which pots require water. An effective method is that shown in the picture. The pots are tapped gently on the outside with a small wooden hammer. If the sound is hollow, water should be given, but if there is a full and solid sound, then the watering is unnecessary. The hollow sound is due to the fact that the mould has contracted and shrunk from the sides of the pot owing to dryness.

HOW SHIPS ARE WARNED IN A FOG

In foggy weather it is, of course, quite impossible for ships steaming or sailing round our coasts to see the lighthouses, buoys, or signals that in normal and fine weather serve as landmarks. Everything at a distance is obliterated, and only by sound can a warning be given. At suitable points round the coasts powerful sirens have been erected, and when the weather is thick these are sounded, different sirens giving different sounds. The sound is produced by air being driven with great force through the holes in two perforated discs, one disc being fixed and the other revolving. The shrillness of the sound depends on the force of the air and the speed with which the disc revolves. The sound is magnified by hugh horns, just as we magnify the sound of a gramophone, and sometimes two horns are used for one siren.



HOW A TIN WITH A STIFF LID MAY BE OPENED

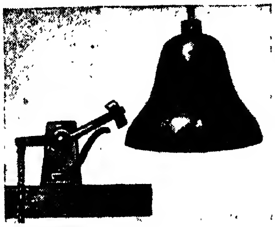
Very often we buy a flat tin of polish or ointment, and find extreme difficulty in removing the lid. No amount of pressure exerted by the fingers will move it, and to attempt to insert a knife under the rim of the lid and prise it off is dangerous, and, if successful, leaves the tin dented and unsightly. A very simple operation will get over the difficulty. We should place the tin flat upon the table, and while we hold it with the left hand we take a stick or any other hard wooden object in the right, and strike the edge of the lid all round sharply, taking care to strike downward. After doing this there will be no difficulty in removing the lid. The striking all round has loosened the substance inside, and each rebound from a blow gives the lid a tendency to spring up from the box.

HOW A BUILDER MARKS A STRAIGHT LINE

It is often necessary for a builder to mark a straight line of considerable length on a wall or pavement, and to draw this in the ordinary way with a rule and piece of chalk would be tedious and difficult. He takes a piece of string of a little more than the required length, and covers it well with chalk by drawing the string several times across a lump of chalk. Then he gets two men to hold this, one at each end, just where he wishes to draw the line. The men pull the string quite taut, as soon as the exact place is covered, and then the builder takes the middle of the stretched string lightly between his thumb and forefinger, pulls it an inch or so from the wall or pavement, so as to stretch it, and then lets it suddenly go. The string springs back to its original position with a jerk, and leaves a distinct and perfectly straight chalk line on the wall.

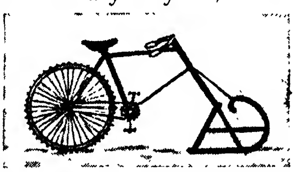
HOW A CHURCH BELL IS RUNG

There are various ways of ringing large bells, such as those hung in cathedrals and churches. They may be swung so that the hanging tongue strikes against the inside rim of the bell; the tongue itself may be swung to strike the bell inside; or a clapper outside may be made to strike the exterior surface. The last-mentioned is the most common method, as it is least likely to cause cracking of the bell. The hammer is on the end of an angular bar, or bent lever, working on a pivot. It is moved by the pull of a rope, and a spring throws it back instantly from the bell after it has struck. The picture illustrates this last method, and shows exactly how the clapper works.



HOW AN ICE BICYCLE WORKS

In countries like Canada, where there are large stretches of ice for a considerable period of the year, ice bicycles are much used. These are not like ordinary bicycles, which would skid and sideslip. They are constructed as shown in the picture. In front is a runner, which is really a giant skate-blade, that glides over the ice with very little friction. At the back is a wheel with a toothed rim for gripping the surface of the ice, and enabling the machine to move forward as the rider pedals. The chain connecting the pedalling apparatus with the toothed wheel is similar in principle to that of an ordinary road bicycle. Tremendous speeds can be attained on these ice bicycles with very little exertion.

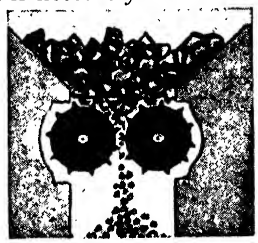


HOW A RELEASING HOOK WORKS

It is often necessary to have a hook to which a chain can be attached, but from which the chain can also be detached in a moment, particularly when it is out of reach. For this purpose a special kind of releasing hook is used, and the picture will show the ingenious yet effective device which facilitates the detaching operation. There is a pivoted lever on the hook, and to this a lanyard, or rope, is attached. When the chain is on the hook, its own weight, together with any pull there may be upon it, keeps it down; but directly circumstances render it necessary to detach the chain, all that need be done is to pull the lanyard, when the lip of the lever rises and throws the connecting link off the hook.

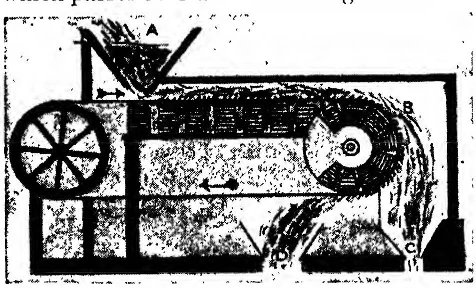
HOW COAL IS BROKEN UP SMALL

Coal as sent up from the mine is mostly in large blocks, far too big for use in fires and furnaces, and it is necessary that these blocks should be broken up small for the consumer. The general method of doing this is to pass the coal through massive rollers fitted with spikes or ridges, as shown in the picture, which represents a section through a roller coal-crusher. The large coal falls into the hopper at the top, and feeds itself into the rollers, whence it falls below into trucks placed ready to receive it. The machine is driven by a steam-engine, and immense quantities of coal are broken up every day in this way.



HOW IRON ORE IS SEPARATED

After iron ore has been dug from the earth and crushed, the metal part has to be separated from the other rock, and this is done by means of magnetic separators. These are of various forms, but the picture given here will show the principle in all of them. The crushed ore falls from a hopper, A, upon a travelling apron, or belt, which passes over a series of magnets, which attract the metal and hold it to the apron. When the apron passes over the drum at B, the non-metallic part of the ore falls by gravitation into the hopper C, while the metallic part continues to be held by the magnets to the apron until the apron comes to a part where there are no magnets to attract it. It then also falls by gravitation into a hopper, D, placed to receive it, and thus the metal is separated from the rock.



HOW A COMMUNICATION CORD WORKS

EVERY railway carriage has its communication cord inside by which help can be summoned in the case of need. It may seem a mystery that, when the cord is pulled, the particular carriage where the pull was given can be identified, but there is really no mystery about it. An ingenious mechanism is set in motion by the pulling of the cord, and three distinct results are brought about. In the first place a rod at the back of the carriage is turned round, and the changed position of a flat disc at either end of the rod indicates the carriage where the cord was pulled. The turning of the rod releases a spring, and a loud whistle is set sounding, while by a still further connection the brake is partially operated, slowing down the train at once. The picture shows the rod with its end discs, the whistle, and the brake connection.

HOW A HOLLY BUSH PROTECTS ITSELF

EVERY one knows how the holly bush protects itself from the ravages of cattle. The leaves are covered with very sharp spines so arranged that they point in all directions, but there is a very striking characteristic of the holly that is not so well known. In an animal it would almost be regarded as a sign of intelligence. When the holly has reached a height of about eight feet and has ceased to be a bush, but is then a small tree, it no longer produces spines on its leaves. They become as smooth and harmless as laurel leaves, the spines being no longer needed for purposes of protection, as the cattle cannot reach so high with their mouths. The photograph shows upper and lower leaves from the same holly-tree.

HOW THE WALLS OF A SHIP ARE BUILT UP

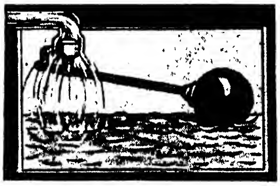
THE modern vessel, whether it be a merchant ship or a man-of-war, is built of metal, and it is interesting to see the way in which the outer plates are riveted to the frame, so that the water shall not get through. There are three methods of doing this. The first method is called the In and Out System, the plates being arranged alternately over and under. A second system is that known as the Clinker System, and in this the plates lap regularly, so that in each plate one edge is under and the other over an adjoining plate. The third method is called the system with the Inner Strakes, or plates, doubled. It will be seen that this system has the great advantage of presenting a flush outer surface, the joinings of the plates being covered by another plate underneath.

HOW DESSERT FRUIT IS GATHERED

THE choice forms of fruit which are used for dessert, and depend very largely upon their appearance for their marketable value, cannot be gathered like ordinary fruit in a rough and tumble fashion. Dessert fruit has to be gathered with the greatest care in the manner shown in the picture. The fruit itself must not be pinched or handled in any way. The stalk alone is grasped, and the fruit is then laid carefully in a chip basket or some such utensil, and protected by tissue paper.

HOW THE BALL OF A CISTERN WORKS

EVERYONE knows that there is a large metal ball inside the cistern, which works a valve, but exactly how the operation is performed is not very generally understood. The ball is attached to the arm of a lever, the end of which is pivoted so that the arm will work freely up and down. To this arm is attached near the pivot a plug that fits the mouth of the inlet pipe. The ball, being hollow, floats on the surface of the water. When the tank is emptied, as the water level falls the ball also falls, and this removes the plug so that water at once flows in. The water in the tank thereupon gradually rises, carrying up the ball with it, and when the cistern is full the lever arm is horizontal and the inlet pipe once again plugged.



HOW DELICATE FLOWERS ARE PACKED FOR MARKET

THE greatest care is taken in the packing of the more delicate kinds of flowers for the market, especially when frost might spoil the blossoms. It is important not only to keep the air out, but also to pack the flowers in suitable material, so that no jarring of the box shall fracture the stems or crush the blooms. A fairly common method of doing this is shown here, where delicate sprays of lily of the valley are seen packed very carefully with layers of cotton-wool. This wadding has the additional advantage that it can be easily moistened.

HOW A LUMINOUS FOUNTAIN IS LIGHTED UP

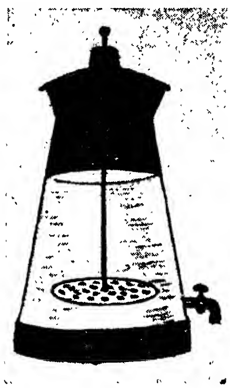
IT may puzzle you to know how a cascade of water from a fountain can be illuminated at night so as to appear like a fountain of liquid fire, but this diagram explains the matter. The water is pumped up through a nozzle, and at the bottom of the nozzle—at the place marked A—is fitted a stout disc of plate glass. Then just below the glass disc is arranged an arc light with a concave mirror to concentrate the rays of light upon the disc. The rays brilliantly illuminate the whole of the water jet, which sparkles like fire.

HOW SHIPS SIGNAL AT SEA

THERE are various ways in which ships signal at sea. The most general method in daylight is by code flags and pennants, these being arranged according to an international system of signals. But sometimes, owing to weather conditions or distance, it is not easy to distinguish the colours, patterns, or shapes of the flags, and then other methods have to be adopted. Chief among these is a system of exhibiting cones, balls, and drums, various orders and positions representing different things according to the recognised international code. Here are some examples. No. 1 means, Show your ensign; No. 2, Is war declared? No. 3, War is declared; No. 4, Beware of torpedoes, or channel is mined; No. 5, Enemy is in sight; No. 6, Keep a look-out; enemy's ships reported about, disguised as merchantmen.

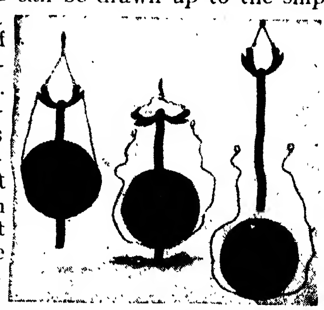
HOW THE MILK IN A CHURN IS KEPT UNIFORM

WHEN milk is being taken round from house to house, some means have to be adopted by which the milk can be kept uniform in consistency. As it stands in the delivery churn, or can, the cream will obviously rise to the surface of the liquid, with the result that the lower milk drawn from the tap will be of poor quality, and even be below the legal standard. In order to get over the difficulty, up-to-date dairies have their delivery churns fitted with a stirrer, as shown in this sectional drawing. This can be worked up and down by means of a handle, and an occasional stir keeps the cream well distributed throughout the milk.



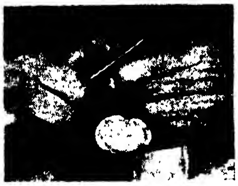
HOW SAMPLES OF THE OCEAN-BED ARE OBTAINED

SAMPLES of the ocean-bed from a depth of as much as four miles are obtained by means of an instrument known as a Brooke sounder. It consists of a ball sliding on a hollow tube, so arranged that when the tube touches the bottom the ball is detached, and the tube can be drawn up to the ship again, with a specimen of the ocean-bed inside. The first picture shows the arrangement as it appears when it is being let down, the weight carrying it down until it strikes the bottom with such force that the tube is driven into the bed, some of which goes up into the tube. When this happens, the ball is driven up, the links holding both tube and ball are displaced, the wires supporting the ball are released, as in the second picture, and the ball falls to the ocean-bed, leaving the tube free to be pulled up, as seen in the third picture.



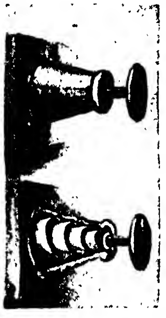
HOW POTATOES ARE PREPARED FOR PLANTING

THERE are various ways in which potatoes are planted for the production of the ensuing crop, and farmers are agreed that the most satisfactory method is to plant small, whole potatoes. Sometimes, however, it is desired that a new variety shall multiply rapidly, and there the stock of seed potatoes is necessarily small. The method then pursued is to cut the tuber up into pieces, each fragment containing an eye. The pieces are then planted.



HOW A RAILWAY BUFFER WORKS

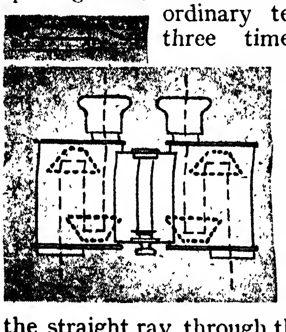
WE all know the buffers of a railway carriage are fitted in such a way as to prevent injury to it or the passengers from the more or less violent contact when the engine runs up to the carriages to join on. The buffers, acting as cushions, break the violence of the collision, and no harm results.



The round plate of steel which actually receives the contact of the next carriage is called the follower. This is attached to powerful springs inside an outer steel casing, and here the blow is broken.

HOW A ZEISS BINOCULAR TELESCOPE WORKS

THE Zeiss binocular telescope, in shape and size very much like a pair of medium opera glasses, has the same range as an ordinary telescope two or three times its length. By arranging in the framework of the binoculars a series of reflecting prisms, so that the ray of light, travelling backwards and forwards between these, covers the same distance as the straight ray through the long telescope, the same result is obtained.



Imagine a piece of wire of a certain length bent as in the first diagram, so that the distance between the two ends is greatly shortened, and you have the idea of the Zeiss binocular. The observer does not look straight through the instrument at the object, but sees merely a reflection of it on a prism. The second diagram shows how the ray of light from the object is bent and lengthened in the instrument.

HOW THE ARCHER FISH CATCHES INSECTS

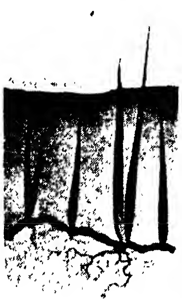
IT may seem strange that a fish should be able to catch insects, yet this is what the little archer fish of the East Indies does, and its method of securing its prey is very clever. The fish, six or seven inches in length, watches for insects by the shore, and when it sees one alight on the vegetation it spurts a jet of water upon the creature with unerring aim and washes it down. Then instantly, before it can escape, the insect is seized and eaten.

HOW A MAN CONNECTS CORRIDOR CARRIAGES

IF you watch a railway porter fastening together the concertina-like connections of two corridor carriages, you will notice that he stands upon the buffers; but there is a right and a wrong way of doing this, and the right way is shown in the picture. When he stands in this way, with his feet resting upon what are known as the buffer-guides, he is quite safe, and the position is a common one, not only for connecting the corridor gangways, but also for attaching and detaching lamps, and so on. Now and again, however, a man will place his feet upon the buffer-rods, which work backwards and forwards in these guides, and although, if the train is absolutely stationary, with no engine attached or near, this may be all right, yet it is a wrong and foolish way to stand on the train, for the least push by an engine would make the carriages run together, the buffer-rods would be pressed into the guides, and the man's feet would be crushed.

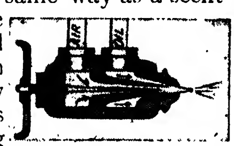
HOW GRASS GROWS ON HARD GROUND

It may be a matter of surprise that tender young grass can ever force its way up through hard ground. The picture will show how this is done. The principle is the same as that of opening a tin of condensed milk. The sharp point of the tin-opener is first inserted in the tin, and when an entrance has been forced the blade can follow. So it is with the grass. Each blade has a fine point, which, by the mysterious power of growing life, forces its way between the particles of soil, however tightly they may be packed together, and thus a passage is made for the blade to follow.



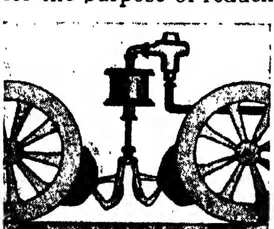
HOW OIL IS BURNED IN A FURNACE

In a furnace where oil is burned, the petroleum is not poured upon the flames in an ordinary liquid stream. It is atomised—that is, broken up into tiny particles, in the form of a spray—by the apparatus shown in the picture. The breaking up of the stream of oil is done by compressed air, very much in the same way as a scent-spray is worked. The petroleum is supplied to the nozzle through a pipe, and the flow is regulated by means of a needle-valve fitting in the nozzle and worked by a screw and wheel. Behind the oil-pipe is another pipe, through which compressed air enters and plays upon the oil, breaking it up into a spray and throwing it into the furnace, where the minuteness of the particles enables the flame to seize every part of the oil instantly, thereby creating intense heat.



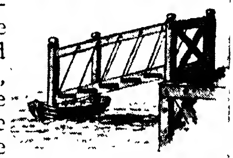
HOW A LOCOMOTIVE AIR-BRAKE WORKS

This picture will explain how a locomotive air-brake works so that pressure is put upon the rims of the wheels for the purpose of reducing their speed and finally stopping their movement. An air-cylinder, operated by the driver from his cab, has a piston directly connected with links that in their turn are connected with the sectors or frames which press the brake-shoes. When the driver wishes to stop his locomotive, he applies the brake by pulling a lever. This puts on the air pressure, which drives the piston down, pushing the links and sectors, which drive the shoes hard against the rims of the wheels of the engine. The locomotive quickly comes to a standstill.



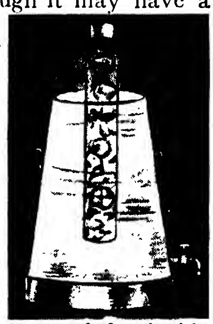
HOW A BOAT LANDING MOVES WITH THE TIDE

A landing-stage for boats in a tidal river must of necessity be so arranged that it will rise and fall with the tide, and no matter at what level the water may be, whether high or low, the landing-stage must provide easy access to the shore. The matter is arranged by having pivoted steps. The stringers (or supporting timbers) are pivoted to the fixed framework on shore, and at low water the landing-stage is in the position shown in the second picture. One edge of each of the steps is pivoted to the lower stringer, and the other edge to the upper stringer, by means of a hanger. As the water rises and carries up the stage, the steps adjust themselves to the horizontal position, until at last, when the stringers themselves are horizontal, the steps are on one plane, and form a level floor.



HOW MILK ON THE ROUND IS KEPT SWEET

In hot weather milkmen are greatly troubled by milk going sour in the churns during the time that they are delivering it from house to house. This is due to the fact that the churn is exposed to the sun, and, although it may have a covering, the heat often turns the milk. In order to keep the milk cool, a simple device is now adopted by all up-to date dairies. An ice cylinder is suspended inside the churn, and the milk, being in contact with this all round, is kept at a low temperature that prevents its turning sour. The method in which the ice-vessel fits inside the churn is shown in this sectional drawing. In very frosty weather the same cylinder can be filled with hot water, and the milk is thereby prevented from freezing.

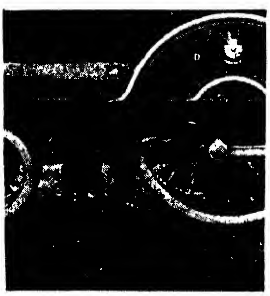


HOW ROCKS ARE BLASTED

THE blasting of rocks for quarrying is much safer and easier than in the days when there was nothing but gunpowder to use. Gunpowder explodes on ignition, but the higher explosives need a detonator—that is, something that will cause a violent shock. A detonator is a metal cap containing so many grains of a chemical known as a fulminate, and it is this fulminate that produces the violent shock needed. The detonator is generally exploded by an electric fuse, which is a small metal tube with connecting wires attached, the ends of the wires being placed in a combustible or explosive powder. These wire ends are connected either by a combustible substance which will catch light when the current is turned on and explode the fulminate, or by a thin wire embedded in a substance called priming. The current makes the wire incandescent ; this ignites the priming, which ignites the fulminate and detonates the charge of high explosive. A fuse of this kind is shown in the picture. It is called a low-tension fuse.

HOW A LOCOMOTIVE GRIPS THE RAILS

DOWN by the great driving-wheels of a locomotive may be seen small copper pipes, which are connected with a metal box that is filled with fine sand, and by a device in the cab of the locomotive the driver can release a valve so that the sand will trickle through the pipes on to the rails. This is done in wet and foggy weather, when the rails, through the moisture, become very slippery and the wheels of the engine are unable to obtain a good grip. Were it not for this device heavy trains would very often be brought to a complete standstill.



HOW A HEAVY CART IS CONTROLLED ON A HILL

WHEN heavily-laden carts are being drawn up a steep hill-road, there is great danger of the vehicle coming to a stop and then running down backwards, pulling the horse with it. In order to avoid this a simple device is adopted, as shown in the picture. A small wooden roller is fastened by a chain to the hub of one of the wheels, the chain being attached by a swivel to prevent twisting. As the cart goes up the hill this roller rolls easily over the ground, but should the cart begin to run down hill backwards the roller will act as a brake. It gets wedged between the rim of the wheel and the rough road and brings the cart to a stand.

HOW SHIPS PASS IN THE NIGHT

IN modern times, when thousands of ships are passing to and fro at all hours of the day and night, it is necessary that there should be some system by which they should recognise one another in the dark, and each know the route and direction an approaching vessel is taking. This is done by a system of lights—red, white, and green lamps being used, and a series of international rules as to the arrangement of these has been agreed upon to prevent collisions at sea. Some of the light arrangements are shown in these pictures, where the plain circle or triangle is a white light, the black a red light, and the grey a green lamp. The first ship is a steamer under way, the second a steamer out of control, the third a steamer towing, the fourth a sailing ship under way, the fifth a fishing vessel trawling, and the sixth a cable ship.

HOW INDIARUBBER IS COLLECTED

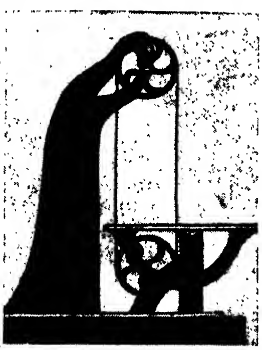
THESE pictures show two ways in which the juicy milk that solidifies into indiarubber is collected from trees. In one case, a row of small, upward cuts, piercing the bark and penetrating the wood, is made, and under each cut a small clay cup is stuck to the tree. The juice trickles into the cups for an hour or two. The next day this is collected, and another series of cuts made lower down. In the other case, the bark of the tree is removed for a height of about three feet, a clay gutter is stuck round the tree, and a series of small cuts made in the wood, through which the juice trickles down into the gutter, and thence through a lip into the vessel placed below.

HOW BLOCKS OF COAL-DUST ARE MADE

In certain districts a very familiar, popular, and cheap form of fuel is sold in the form of square blocks made up of compressed coal-dust. Loose coal-dust is, of course, a poor fuel for domestic grates, and, used in any quantity, soon puts out the fire or makes it burn dull. By pressing the dust together until it forms a solid block, this difficulty is got over, and the picture shows how the blocks are made. The fine dust is fed down from a hopper to a ram, which works horizontally, and the outlet or nozzle for the dust tapers sufficiently to give the ram the necessary resistance to compress the dust into a solid cake before it passes out at the nozzle.

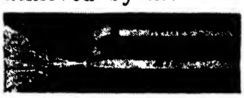
HOW A BAND-SAW WORKS

The circular saw, which consists of a rapidly revolving steel wheel with a toothed edge, is very effective, and saws up beams and planks in a remarkably short space of time, but it is only useful where straight sawing is required. For sawing in curved lines, a band-saw has to be used. This consists of a continuous steel band with one edge toothed, revolving rapidly over wheels, very much as a belt revolves over pulleys. The band-saw is, of course, stretched quite taut, and the picture shows how the appliance is arranged. The bottom wheel is usually out of sight under the saw-table. For sawing metals, there is generally a third wheel, set back with the framework, in order to allow room for the manœuvring of large plates.



HOW PAINTING IS DONE BY SPRAYING

More rapid methods of painting large objects and surfaces than can be achieved by the old-fashioned paint-brush are coming more and more into use, especially in the United States, that land of ingenious labour-saving appliances. The most popular method is by means of spraying. In this method a stream of paint is broken up by means of compressed air into a gentle spray that falls evenly upon the object to be painted, so that it has a surface uniform in colour. The air is ejected through a nozzle and plays upon the paint, which is fed through a side pipe. A conical nose-piece is flattened to a very narrow opening, and this projects the spray of paint in a thin sheet upon the object.

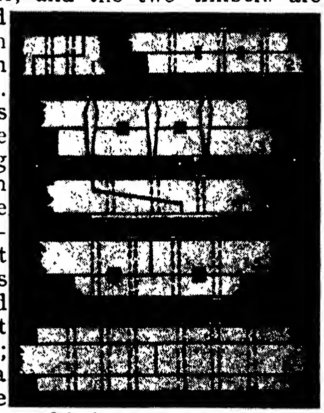


HOW A TREE IS TRANSPLANTED

The transplanting of tall trees is a delicate operation requiring great care and skill, but it is often necessary in landscape gardening. The most common method is that shown in the picture. A space is dug all round the roots of the tree, which, with the adjacent soil, is bound round with boards or sacking, and the whole is then raised by a high-framed truck fitted with a double hoisting tackle. When the tree-roots are above the level of the ground, the truck is wheeled to the spot where the tree is to grow, and the whole is then lowered by the ropes and pulleys into a hole dug ready to receive it.

HOW TIMBER IS SPLICED

The splicing or joining of heavy timber beams in building operations is a work needing great skill, and various methods of splicing are used. Some of the most common methods are shown in these pictures. The ends to be joined are cut in various ways and fitted together, and the two timbers are then bolted together with iron or wooden keys and bolts. Sometimes iron plates are placed along the joint, in order to give greater security. The first picture shows what is called a straight splice bolted; the second, a lap splice with iron keys and bolts; the third, a lap splice with oak keys and yoke straps; the fourth, a scarf and butt joint with one iron plate, bolted; the fifth, a butt joint with timber fish-plate, keyed and bolted; and the sixth, a butt joint with double timber fish-plates, bolted.

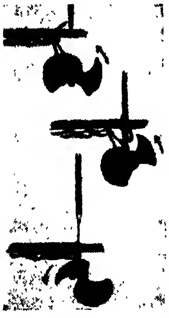


HOW A LIGHTSHIP IS MOORED

A LIGHTSHIP has to be very securely fastened so that it may remain practically in one place always, and yet ride with the tide. For this purpose three mushroom anchors are used. Not only are these very heavy, but their shape makes them much securer than ordinary anchors. The anchors are placed in the position shown in the picture, and where the cables attached to these join together there is a swivel, to which also the cable to the ship is fixed. The swivel cannot move beyond rising and falling slightly as the anchor cables lie on the bottom of the sea, and the lightship cannot swing far with the tide.

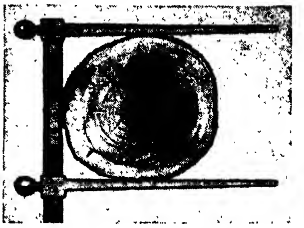
HOW A SEWING MACHINE MAKES A STITCH

THERE are, of course, various forms of stitch made by sewing machines, but they are all made on the same principle; and the diagram here given of how a common chain-stitch is made will give a very good idea of the principle. The stitch is effected by the double work of the threaded needle and the bobbin, or spool, whose position is just below that part of the table of the machine on which the needle moves up and down. As the needle goes down with its loop of cotton, the bobbin moves round or forward and catches the needle's loop, which is held and tightened as the needle goes up again, and thus the stitch is formed. Again the needle comes down and the same process is repeated, and so a row of stitching is made with very great rapidity.



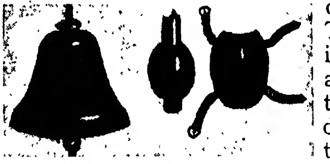
HOW GROWING TREES ARE MEASURED

GROWING trees are often bought for timber. In order to get at the quantity of wood, the modern method is to take true measurements by means of a calliper, an instrument that can be adjusted to the trunk of any tree so as to record its diameter. The instrument has a movable arm working up and down on a rule graduated in inches and tenths of an inch, and at the end of the rule is a second arm, fixed. The calliper is about three or four feet long, and its arms are usually half the length of the rule. A typical calliper is shown in the picture. With the diameter and the height, the amount of timber in a tree is easily calculated with accuracy. The diameter halfway along the stem is taken by the calliper, the area of the cross-section is then found by squaring the radius and multiplying by 3·14, and the result multiplied by the length of the stem gives the cubic contents.



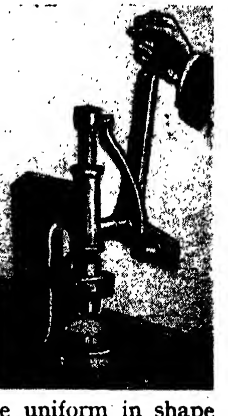
HOW BELLS ARE MUFFLED

CHURCH bells are sometimes made to ring a muffled peal, and the muffling is done by attaching a leather pad to the hammer of the bell. This is kept in position by a strap, and the required density of tone is obtained by padding the leather guard with wool to the required thickness. If the peal is to be half muffled, only one side of the hammer is covered by the pad, the result being that clear and muffled blows are struck alternately. When the peal is to be fully muffled, the hammer is padded on both sides, so that no clear blow is struck.



HOW A MACHINE MAKES PIES AND TARTS

THE pies and tarts sold by large confectioners' and bakers' shops are not made by hand in the old-fashioned, slow way familiar to the housewife. They have to be turned out at a rate ten times faster than any hand method could render possible, and for the purpose a machine is used, which is shown in the picture. The dough is shaped in moulds by the pressure of a die worked by a lever or handle, and the dies and moulds can be changed according to the shape desired. By using this machine, the crusts are uniform in shape and thickness, and less dough is used.

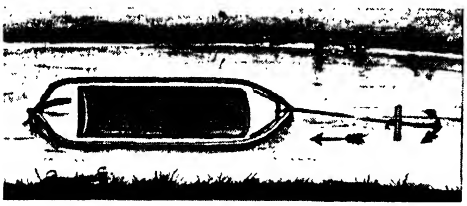


HOW TURNIP STORES ARE KEPT COOL

When large quantities of turnips are stored, they are covered with straw and earthed over to keep them from harm through frost. There is a danger, however, that heat may be generated internally, and harm done to the turnips thereby. In order that the temperature may be kept even and any hot air allowed to escape, drain-pipes are arranged at intervals, as shown in the picture. Sometimes, instead of pipes, a bunch of straw is placed here and there, and this keeps open a passage for the escape of the warm air from inside.

HOW A FERRY-BOAT IS WORKED BY THE CURRENT

An ingenious method of utilising the current of a river for the purpose of sending a ferry-boat backwards and forwards is shown in this picture. The boat is anchored firmly to the middle of the bed, the rope connecting the boat with the anchor being sufficiently long to allow the boat to



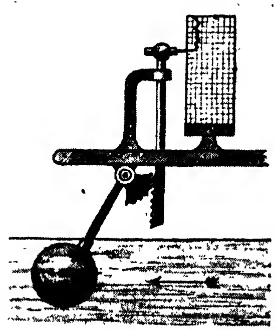
reach either bank. By simply turning the rudder so that the current will drive against it, the boat may be made to go either to the right hand or to the left. No other motive power than the current is required. Of course, such a system can only be used on streams with little or no traffic.

HOW A TRAWL NET WORKS

The trawl net of an old-fashioned fishing-trawler was kept distended by a beam of wood, but the weight of the beam was naturally a handicap, and kept the net to small dimensions. The net of a steam-trawler, however, has a mouth a hundred feet wide. In place of the beam is a stout steel wire attached to a board at each end. These boards are connected with the warp, or rope, by which the boat drags the net, by means of small chains so arranged that as the boards pass through the water they are kept almost vertical, but slanting slightly away from each other. The result is that they stretch the net wide open, and as this passes along a rope drags the bed of the sea, and drives up into the net any fish that may have been resting. An arrangement inside like a lobster trap prevents the fish escaping.

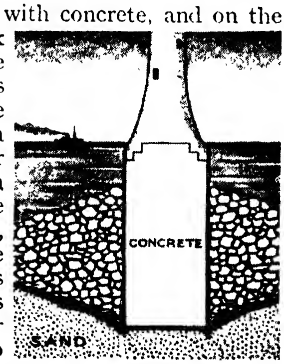
HOW THE VELOCITY OF WATER IS MEASURED

It is often necessary to measure the velocity of a river, and the picture shows the kind of apparatus by which this is done. The floating ball, driven forward by the current, moves the connecting arm, which by a toothed arrangement lowers a perpendicular rod, and a pencil attached to this marks a line upon a card placed in position for the purpose. The card is divided into sections, and by making a time-test the speed and regularity or otherwise of the current is easily and accurately arrived at, and a pictorial record obtained.



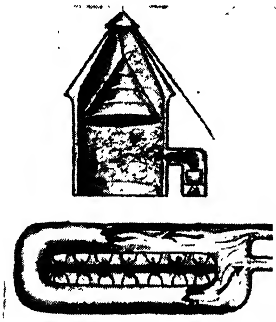
HOW A LIGHTHOUSE IS BUILT ON SAND

It is sometimes necessary for a lighthouse to be built on sand, and the method of doing so is shown in the picture. A great hollow caisson, or tube, is sunk for a considerable distance into the sand, with its top just rising above the water. The inside is then filled up with concrete, and on the artificial rock thus formed the lighthouse is erected. The caisson has a strong steel floor near the bottom on which the concrete can rest, and the whole monster tube is sometimes as great as sixty or seventy feet deep and forty feet or more in diameter. All round the caisson mattresses of brushwood are lowered on the sand, and these are kept in place by dumping on top hundreds of tons of stone until the shoal is covered with a solid mass that will defy erosion.



HOW LAMPBLACK IS MADE

LAMPBLACK is a very important commercial commodity, used largely in the making of paints and inks and in other ways. It consists of almost pure carbon in small particles, and there are two ways of making it. One is to burn crude oils in a confined space with little air, so as to generate as much smoke as possible, this passing into a receptacle known as a lampblack furnace, where the resultant soot is collected. Another method is to allow gas-jets to burn in such a way that the flames play upon iron cylinders, through which flows a stream of cold water. Soot gathers on the cylinders.



HOW A FOLDING LADDER WORKS

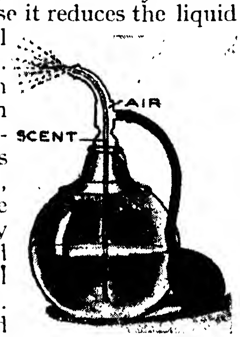
IT may seem difficult to conceive of a ladder that will fold up until it is, in compass, little more than a line-post. There are collapsible ladders, but these are made in sections. The fold-up ladder is, however, made on quite a different principle. The rounds, or rungs, are flat, and are pivoted at each end to the uprights, or side-pieces. When the ladder is in use it appears like any ordinary ladder, but when it is desired to fold it up one side is pushed up and in towards the other, the pivoted rungs slant upwards and fit into recesses in the uprights, and the whole ladder looks like a post. Such ladders are very useful for carrying about, and they need little space for storing.

HOW A FURNACE IS STOKED MECHANICALLY

IN many large up-to-date works, and in most gasworks, the furnaces are now fed by appliances known as mechanical stokers. These work far more evenly and more satisfactorily than the old-fashioned hand method of stoking. The picture shows one form of mechanical stoker in general use. The coal passes from a hopper on to a moving grate, which works on the principle of the endless chain, and the fuel is thus carried into the furnace at a uniform rate, which can be regulated. A rack and gear worked by a lever regulates the quantity of coal fed from the hopper. Other mechanical stokers use the principle of the spiral screw for conveying the coal into the furnace, while others, again, have a plunger, operated directly by a steam piston, which pushes the charge of coal forward.

HOW SCENT IS DIFFUSED BY A SPRAY

AN apparatus for changing a liquid to a spray for disinfecting, perfuming, or other similar purpose, is technically known as an atomiser, because it reduces the liquid to atoms, or very small particles, or drops. The principle on which it works is shown in the accompanying picture. The liquid runs through a narrow pipe, and is met at the mouth, or nozzle, by a blast of air, pumped by an indiarubber ball or some other means. This powerful wind blows the liquid into countless drops, which, being so small and light, fall gently all around, and we thus have the spray. The lady's scent-spray and the apparatus used by hairdressers for applying bay rum to the hair are familiar instances of atomisers.

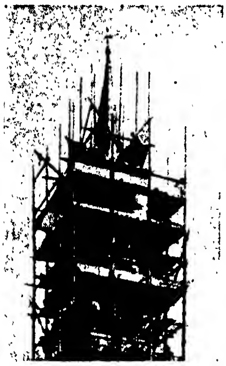


HOW A DOMESTIC OVEN IS HEATED

IN the old forms of kitchen ranges the oven was heated on one side only—that in contact with the fire. The result was that, in cooking, a joint or cake always had to be turned so that first one side and then the other was actually near the fire. In modern scientific ranges, however, this has all been changed. The whole of the oven is now properly heated. A space is left right round the chamber, between its walls and the outside surfaces of the stove, and the draught is so arranged that the flames and heat from the fire will be carried right round the oven, giving equal heat on all sides, as shown in the picture.

HOW A CHURCH-TOWER IS REPAIRED

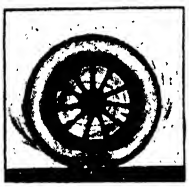
THE repair or restoration of a church-tower is far from being a simple matter. With an ordinary house a travelling cradle can be let down from the roof or upper windows, and this can be raised or lowered according to the part of the walls requiring repair. But with a church-tower more elaborate arrangements are made. If it need thoroughly overhauling and restoring, a great network of scaffolding has to be built up round the tower, so that the workmen can get to every part of the walls.

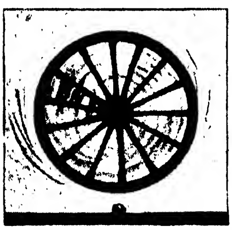


The building of such a scaffolding is a work that needs great skill, and is costly to carry out. Hundreds of pounds are often spent in building up and removing the scaffolding itself, and many tons of timber are used in its construction. No simpler method that is equally effective has yet been invented.

HOW A PNEUMATIC TYRE MAKES RIDING EASY

ALL those who are in the habit of riding bicycles or motor-cars know how comfortable travelling is made by the use of pneumatic tyres, and none appreciate them more than those who used to ride cycles with the old-fashioned solid tyres. The pneumatic tyre gives comfort, and the reason is not very generally known, but these two pictures will explain the matter. When an ordinary wheel of a cart or other vehicle is passing over a road and meets any obstruction, such as a stone, it is jerked into the air by the sudden contact. If, however, the wheel be fitted with pneumatic tyres, the inflated rim gives to the stone, as shown in the first picture, and the jerk caused by the contact is almost entirely avoided. Further, pneumatic tyres help to increase speed by keeping the wheels continuously moving forward, instead of periodically jumping vertically owing to contact with stones.



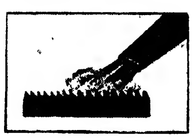


HOW A BAT SLEEPS ON A WALL

IT may seem a matter for wonder that a bat can go to sleep hanging to the face of what appears to be an almost level and precipitous wall. But when we know exactly how the hind feet of the bat are formed, its ability to hang almost anywhere is explained. The bat's hind feet are fitted with very useful claws that are in form very much like the top half of the hooks with which a butcher hangs up his joints. The points of the claws are so sharpened and at such an angle that the very least irregularity in the wall will be sufficient for them to get a purchase, and as the bat's weight is so slight, the pressure upon them is not too great. The picture shows just how the bat suspends himself, and it will be seen that he does not have to grip with his claws as a bird does. In fact, the bat, while hanging in this position, can swing comfortably in the wind without fear of falling.

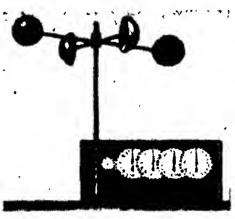
HOW A FILE IS SHARPENED

ALTHOUGH in the making of most tools machinery has superseded handwork, yet in the making of files the hand-made articles still hold their own, being considered far superior to machine-made files. A bar of cast steel is ground by stones to the right smoothness and shape, and the ridges, or cuts, are then made by blows from a very hard chisel while the file rests on an anvil and is held down by two straps. These chisel-cuts, running in parallel lines across the tool, cause a series of ridges, or teeth, to stand up on the surface of the file. But they are not sharp enough for use. So the file is first hardened by being plunged while hot into salt water, and then the edges, or angles, of the teeth are sharpened by being played upon by a blast of very fine sand, that is driven through a pipe or nozzle with tremendous speed and force by means of steam. The sand wears away the steel, and leaves very sharp edges to the teeth. The picture shows a section of a file with the sharpened teeth on the left, and the sand-blast playing upon the unsharpened teeth on the right.



HOW THE VELOCITY OF THE WIND IS MEASURED

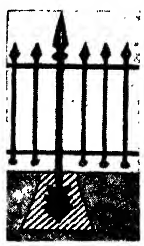
THE recording of wind velocities and pressures is very important in meteorology, and a simple instrument known as an anemometer—that is, wind-measurer—is used for the purpose. We can generally see one at work at any coastguard station.



Four cups or hollow hemispheres catch the blowing wind, and turn a vertical spindle. At the foot of the spindle is a worm which turns a small cogwheel, and this in turn moves a number of other toothed wheels, the principle being very much like that of the gasmeter. Experiment has shown that the cups revolve at about a third of the wind's velocity, and five hundred revolutions of the spindle are made while a mile of wind passes. The under wheels tell the number of revolutions of the cups, and from these the velocity or pressure can be worked out.

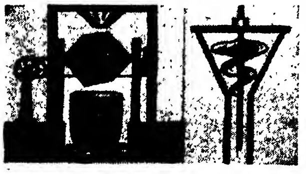
HOW AN IRON FENCE IS FIXED

WE often see a strong iron fence, which is to stand a good deal of strain, standing on a stone pavement, and we may wonder how the metal supports are fixed in the stone so firmly as not to give in any direction. A very common method is that shown in the picture. A cone-shaped hole is cut in the stone base, and into this the end of the iron support is stood. This base has a series of two or three cone-shaped projections, and when it is in position molten lead is poured into the opening in the stone. This soon solidifies, forming a cone-shaped ingot, which, being bigger at the base than at the top, cannot come out. For the same reason the cone-like projections in the metal pillar prevent it from giving.



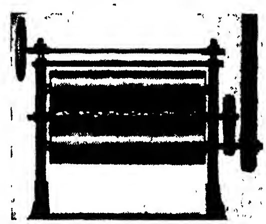
HOW CONCRETE IS MIXED

THE use of concrete on a large scale in building and engineering operations necessitates rapid and thorough methods of mixing. The machinery used for this purpose varies, but the first picture shows a familiar form of concrete mixer. The material of which the concrete is made is fed from a hopper into a rectangular box of iron revolving on trunnions placed at opposite corners. By means of a belt and pulleys an engine turns the box, and the concrete is thoroughly mixed. The iron mixing-box is then opened, and the concrete allowed to fall out into a vessel or dumping car. A simpler form of mixer is the pug mill, which consists of a spiral worm or a series of revolving blades working in a conical shell as shown in the second picture.



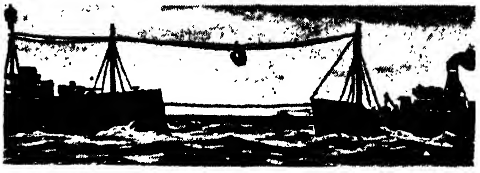
HOW ALLIGATOR LEATHER IS MADE

ALLIGATOR leather, with its more or less square and oblong scales of varying sizes, is exceedingly ornamental, and is in such great request for bags, purses, furniture coverings, and other purposes that the supply cannot keep pace with the demand. The reason is that the supply of suitable alligators is far from inexhaustible. Commercial alligator leather is therefore largely manufactured from skins of other animals, the scale design being embossed on the leather by means of machines specially designed for the purpose. The leather is damped, and impressed with the pattern by passing between copper rollers bearing the exact design of an actual skin. Such a machine is shown in the picture.



HOW SHIPS ARE COALED AT SEA

ONE of the greatest problems for modern navies is to coal their warships at sea. There are various plans for getting over the difficulty arising in rough weather, but none of them can be regarded as so successful as to be the final and approved method. The principle in all, however, is for the warship to take the collier in tow, and then



to have an endless cable, more or less taut, running from a mast or support on the bows of the collier to a similar support near the stern of the warship, and along this to draw the sacks of coal. The difficulty is to keep the endless cable taut. If the ships rock much, it is liable either to sag and allow the sacks of coal to dip in the water, or to get so taut as to snap or unslip one of the supports.

HOW STONE IS QUARRIED BY WOODEN WEDGES

When large, even blocks of stone are wanted from a quarry, these are sometimes broken off from the main mass of rock, not by blasting with gunpowder or some other explosive, but by means of wooden wedges. A shallow trench is first dug by means of a pickaxe, and the wedges are then put in and hammered down as far

as they will go. The wedges are of well-seasoned oak that has been dried in an oven, and as soon as they are properly in position the quarrymen take water and well saturate the wedges. The wood, being porous, soaks up the liquid and swells, and in the swelling the trench is gradually made bigger, until the large block of stone is at last completely detached and can be removed. One advantage of this somewhat elementary method of quarrying is that the stone is not damaged and broken up, as it so often is in blasting.

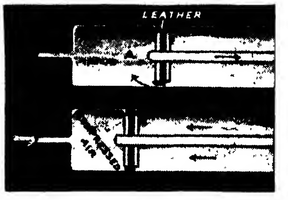
HOW ANIMALS KEEP FLIES AWAY

Our domestic animals, such as horses and cows, are greatly annoyed by the various kinds of flies which settle upon them, and were it not that they had the means of self-defence their condition might be pitiable. It is by means of their long tails that the animals are able to drive off the flies, and on a warm, sunny day, if we watch the horses or cows in a meadow, we shall see that their tails are constantly on the swing. It is this use of the tail which should

prevent anyone from docking a horse's tail. But not only does a horse or pony drive the flies from its own body by means of its tail; it helps its fellows in a similar way, and in its turn receives help from other animals. We have, no doubt, frequently seen animals on a hot day standing in the position shown in the picture. They do this in order to flick the flies from one another's faces, a part of the animal that a horse's own tail will not usually reach.

HOW A BICYCLE PUMP WORKS

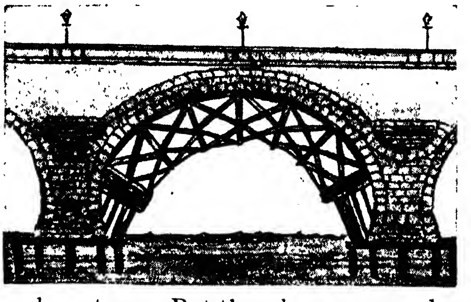
Most of us use a bicycle pump, but perhaps we may not all know just how it works. In these pictures the matter is made clear. Every bicycle pump consists of two parts, a cylinder and a piston on a rod working up and down in the cylinder. The piston consists of two round metal plates, rather smaller in diameter than the diameter of the cylinder, and between these two circular metal plates is a disc, or cup, of leather larger in diameter than the cylinder.



When the handle of the pump is drawn out, as in the top diagram, the air rushes into the pump past the leather cup. When, however, we begin to push the handle in again, the air inside the cylinder, A, pushes the cup out all round, so that it presses against the side of the cylinder, and no air can escape in the direction of the piston and handle. It is therefore compressed, and escapes out of the nozzle of the pump, as shown in the bottom portion of the diagram.

HOW AN ARCH IS BUILT

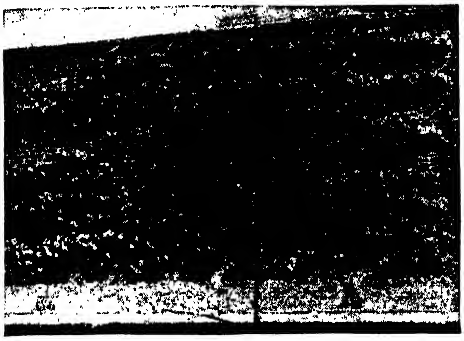
The arch is, perhaps, the greatest invention ever made in architecture. The principle of the arch is that every stone shall help every other stone, and the whole shall be held in position by a top



or key stone. But though we may understand how it is that an arch will stand after it is built, and even support a great weight upon it, we may not know the manner in which an arch is built up in the first place. Before the stones of the arch can be put in position, a great timber staging, with massive struts, has to be erected, capable of sustaining an enormous pressure, and then on and around this the arch is built up until at last the keystone is placed in position.

HOW FRUIT-TREES ARE TRAINED ON WALLS

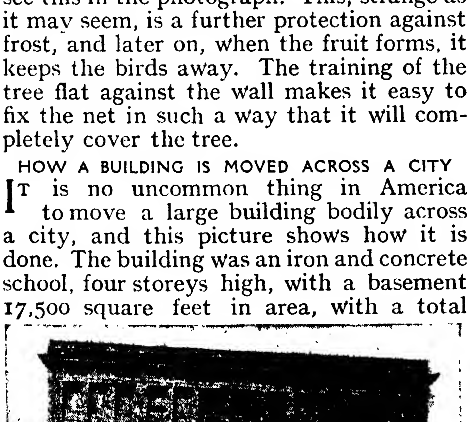
When a fruit-tree is properly trained on a wall, far more fruit is obtained than when it is allowed to grow as it likes, or is merely pruned in the old-fashioned way. By pruning and fastening it in the manner shown, so that it is quite flat, the tree enjoys the maximum of sunshine in every part, with the result that it blossoms



profusely, and is later on loaded with choice fruit. In order to protect it from the late frosts that do so much damage to fruit-trees in England, a glass frame is often erected over the tree, as seen in the photograph. This keeps off the cold rains, and a frost is then less likely to do harm. A net is also spread all over the tree, although it is difficult to see this in the photograph. This, strange as it may seem, is a further protection against frost, and later on, when the fruit forms, it keeps the birds away. The training of the tree flat against the wall makes it easy to fix the net in such a way that it will completely cover the tree.

HOW A BUILDING IS MOVED ACROSS A CITY

It is no uncommon thing in America to move a large building bodily across a city, and this picture shows how it is done. The building was an iron and concrete school, four storeys high, with a basement 17,500 square feet in area, with a total



weight of 8000 tons. It was erected on 66 steel columns embedded in concrete, and all these columns had to be cut through. Then a fresh foundation was prepared on the new site with short steel columns corresponding exactly to the ones already cut. The great building was then underpinned, as shown, and a large number of rollers placed beneath. The route being cleared, the school was rolled along, across five streets, taking two half-turns on the way, and going uphill four feet, and then downhill about four feet, so that the old level was kept to within a quarter of an inch. When the building had been rolled exactly into position, the ends of the steel columns of the school were riveted to the top of the steel columns in the new foundation, the lower walls completed, and the dug-out earth replaced. The whole task was carried out without a single floor being cracked or any part of the building spoilt. The total cost was over £30,000.

HOW CREAM IS SEPARATED FROM MILK

It may seem very puzzling to one who has never examined a cream separator to think that by simply turning a handle the new milk which is poured in at the top of the apparatus will flow out in two streams, all the cream coming from one tap, and all the watery element from another. The picture on this page will show how it is done. The principle used is that of centrifugal force, which means that a substance being whirled round in a circle tends to fly from the centre of the circle in which it is moving. The milk pours into the separator, and flows through a distributor down a

central tube. At the bottom it rises through little holes, A, into the bowl, which, when the handle is turned, revolves about six thousand times a minute. With this tremendous circular movement, centrifugal force drives the milk through a perforated lining to the sides of the bowl, but the watery element, being heavier than the cream, crowds to the sides, and the lighter cream is kept away from the sides. As more milk enters, that already in is forced up, and the cream passes through one opening, while the water passes through another, each being collected separately.

HOW A FLORIST WIRES A ROSEBUD

WHEN we look into a florist's window we often see a number of rosebuds just opening out, and we may wonder why it is that they seem to remain at this stage, and not to open wider until the petals fall. The explanation is that the florist has a method of fastening up the bud so that it shall not open wider. Two very thin wires are passed through the base of the bud at right angles to each other, and they are then bent back and twisted round the stalk, holding also the foliage that may go to the making up of the buttonhole. The thin wires do not injure the flower in any way, and the life of the buttonhole is rendered much longer than it would be if the flower were allowed to open in the normal way.

HOW A TREE IS MOVED

THE process of moving a full-sized tree from one part of a park or garden to another needs a deal of care and patience. A square is first of all marked out on the soil round the foot of the tree, the square taking in most of the roots. Then the soil is cut into, till at last a great cube has been separated from the ground,

and the tree, with its roots and adhering soil, is ready for removal. The next operation is to dig away the ground in the direction in which the tree is to be moved, making a sloping way up which the tree can be drawn. Planks are then put in the slope, and the tree is drawn in an upright position on to these, and by means of a winch it can be moved about in any direction. Guide-ropes are fixed to the upper part of the tree-trunk, and men hold these out in various directions to prevent the tree giving a sudden lurch over as it travels.

HOW SANDY EMBANKMENTS ARE FIXED

IN some exposed parts of the country where the soil is loose and sandy it is difficult to form firm embankments for railways and other purposes, because the wind carries away the sand. To fix the shifting sand by such means as cementing would be out of the question owing to the great expense, but Nature comes to the

rescue of man, and helps him at comparatively small cost to bind the sand into a more or less firm and stable mass. Certain kinds of coarse grass are planted at regular intervals, and as this flourishes it soon spreads and throws out its roots in such a way that the loose soil is held tightly together, and what was little more than a shifting sand-dune becomes a stable embankment, upon which in time even a railway may be built.

HOW THE FREE WHEEL OF A BICYCLE WORKS

THE greatest invention in connection with the bicycle since the safety machine came into existence is the free wheel, and these pictures will show exactly how a free wheel works. When we pedal, the chain moves the toothed wheel round, and a number of notches, or ratchets, inside catch against little movable half-discs of metal called pawls. These pawls move loosely in semicircular grooves, but when they are caught by the notches they, in their turn, catch the sides of the grooves in which they rest, and cause the hub of the bicycle wheel to revolve, as shown in the top of picture. When, however, we press down on the pedal, keeping it still, the chain and the toothed wheel at once stop moving,

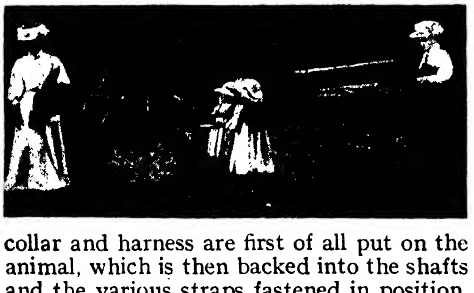
and the pawls slip easily over the notches, because they are moving in the direction opposite to that in which the points of the notches, or ratchets, are turned. When this happens, although the pedal, chain, and outer toothed wheel are stationary, the hub of the bicycle wheel continues to move.

HOW A TREE IS GRAFTED

GRAFTING is one of the most important operations known in gardening and fruit-growing. There are various methods of grafting, but one of the most common is that shown here. The stock of the tree on which the graft is to be put is cut down, and a cleft or wedge-shape aperture is cut in the stock ready to receive the scion, as the graft, or branch, of the new plant is called. The scion is six or eight inches in length, cut like a long wedge or cleft, and this is inserted into the aperture of the stock. The whole is then bound tightly round with bast, and a covering of some such substance as clay put all over the joint. It is essential that the growing layer of the two stocks should be in contact, as the hard wood of one tree never unites with that of another. All the growth above the graft will be of the nature of the tree from which the scion was taken, and this method of treatment enables valuable varieties of fruit-trees to be multiplied at a rapid rate. The time when grafting is carried out is the spring, when the sap is rising in the tree.

HOW A PONY OR DONKEY IS HARNESSED

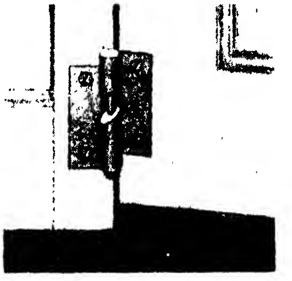
WHEN one sees a pony or donkey harnessed to a cart by a man who understands the business, it may seem a simple enough task, but if a novice were given the harness and had no idea or instruction as to how he should put it on, he would find himself in an awkward position. The method of proceeding is shown in the picture below. The



collar and harness are first of all put on the animal, which is then backed into the shafts and the various straps fastened in position, being drawn through the places provided for them in the shafts. The reins, which have been looped up so as not to get entangled in the animal's feet, are then untied and carried across its back into the cart. All is then ready for a drive.

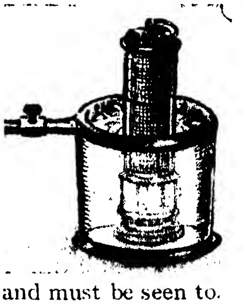
HOW A DOOR IS MADE TO OPEN OVER A CARPET

WHERE a very thick carpet, such as a Turkey carpet, is used to cover the floor of a room, and goes nearly up to the wall, it would be impossible to open the door unless some special means were taken to allow of this. Sometimes the bottom of the door is planed, but the disadvantage of this is that when the door is closed a considerable space is left between the door and the floor, which allows of a draught blowing into the room. The most satisfactory method is to have rising hinges. The two parts of the hinge are made on the principle of the screw or inclined plane, and as the door is opened the part of the hinge attached to it makes a spiral movement on the other half, and raises the door.



HOW A MINER'S LAMP IS TESTED

THE safety of the coal-miner depends so much upon the perfect working order of his lamp that it is not surprising all lamps are tested each day before being taken underground. The method of seeing whether the lamp is in order is simple. It is placed in an instrument called a tester, which consists of a metal pan with a ring of piping round it. This piping is perforated on the inner side, and is connected with a reservoir of compressed air. As soon as the safety lamp, which has to be all ready lighted, is stood in the tester, a tap is turned on, and the compressed air rushes through the holes in the piping and blows upon the gauze of the lamp. If the light burns very much as usual, the lamp is perfectly safe, and may be taken down the mine; but if there is a series of sharp flashes it is defective, and must be seen to.

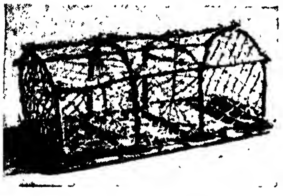


HOW EGGS ARE TESTED

THERE are various ways in which eggs are tested. One of these was given on page 163, but, by a strange slip, the appearance of a fresh egg when held before a strong light was wrongly described. No air-space is seen at the end of a new-laid egg: it is in a stale egg that the air-space appears.

HOW LOBSTERS ARE CAUGHT

THE lobsters which we see exposed for sale in fish-shops are caught by guile. Traps are set and baited with dead fish, and the unfortunate lobsters, eager to get at the food which they like, find the entrance to the trap and go inside. But, once there, they are unable to get out, for the entrance is so made that, while a lobster can find it easily and can slip inside without any difficulty at all, the opening being funnel-shaped, with the widest end outside, the creature cannot find the smaller opening, and so is kept a prisoner. The lobster-trap shown here consists of a wooden frame with a string net covering and an opening in the middle section.



HOW LAMBS ARE CARRIED

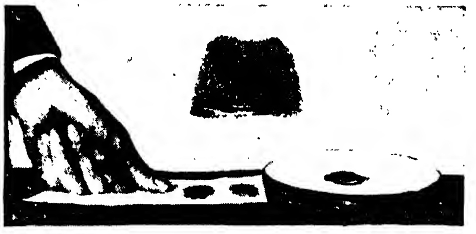
THIS picture shows the right way to carry a young lamb, although to the town-dweller who knows nothing about the handling of livestock it might seem cruel, just as the carrying of a rabbit by the ears seems anything but kind to one who does not understand. If the lamb were taken up and carried in the arms, there would be great danger of the internal organs of the little animal being injured, and by expert experience the way shown has been proved to be the best for the lamb. It will be noticed that the back of the animal faces the direction in which it is going. This is by design, as a lamb is a delicate creature, and if its breast faced the cold winds it would probably catch a bad cold. The two legs are held by the thumb and first two fingers, with the forefinger between the feet. This gives a secure hold.

HOW FLOWERS ARE FERTILISED IN GLASSHOUSES

IN order that fruit may come on our fruit trees and bushes, it is necessary that the blossoms be fertilised, and this is carried out either by insects, such as bees, flying to one flower, getting dusted with the pollen, and then flying to another, where the pollen is rubbed off, or by the wind, which blows the pollen from one blossom to another, or blows the various flowers together. In greenhouses, however, where some of the choicest fruits, such as peaches, are grown, this natural fertilisation is impossible; there are probably neither bees nor wind under the glass. In order that the fertilisation may be effected, the gardener takes either a camelhair brush, or, for the blossoms that are out of easy reach, a rabbit's fluffy tail tied to the end of a stick, as shown in the picture. With this the pollen is collected from one flower and dusted off on to another very effectively, and without injury to the blossom.

HOW FINGER-PRINTS ARE TAKEN

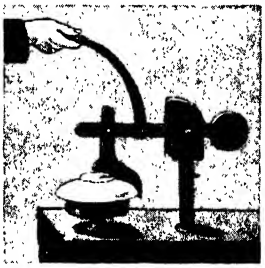
THERE would seem to be an unfailing method of identifying every individual man, and that is by his finger-prints. No two people, it is said, ever have exactly the same markings, and at Scotland Yard the police keep a large file of finger-print impressions, and can turn up any one of them in a moment or two if they want to identify a prisoner. The method of taking these impressions is very simple, and any boy or girl can take finger-prints from his or her own finger, or from friends and relatives. Take a tube of moist sepia paint, and squeeze a drop on to a plate or saucer. Then add a drop of water, and after mixing the sepia and water into a paste, press the finger upon it, turning the finger half over,



so as to ink the whole of the front of it. Then press the finger in the same way on a sheet of clean paper, and when it is removed the impression will be there.

HOW A SAUCER IS MADE

It may seem difficult to imagine how a saucer is shaped if we have never seen a potter at work, but this picture will make the matter clear. A thin disc of clay is first of all beaten out on a revolving table, and then the disc is placed on a mould and pressed down, so that it gets the shape of the inside of a saucer. The outside—the part which will be the bottom of the saucer—next has to be shaped, and this is done by using what is known as a profile tool. This tool is really a shape so cut as to form the roundness of the saucer, and the little projecting circle, or ridge, on which it stands. As the clay revolves on the potter's wheel, this profile tool presses down upon it and shapes it out to the desired proportions. For oval objects and those of other shapes, the method is to press the moist clay into moulds made to the desired shape. Of course, when the shape is complete, the vessel is baked and glazed.

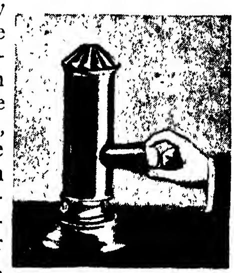


HOW COCOA IS OBTAINED

We drink our cocoa regularly and enjoy it, but though we know it comes from a plant that grows in hot countries, we may not know just how it grows, and the form in which it is gathered ready for the manufacturer. Cocoa is really the seed of the cocoa or cacao tree. The fruit is very much the shape of a cucumber, and is about seven or eight inches long. It is yellow in colour, and ripens to red when the sun catches it. It grows close to the trunk, as shown in the picture. The fruit is gathered and left for several days in heaps to ferment. Then the thick, warty rind is opened, and the very numerous almond-like seeds, or beans, which lie like eggs in a nest, are removed and dried. It is from them that the cocoa we drink is made. Each bean is covered with a thin brown skin, which is taken away, and after the beans have been dried and broken up they are called cocoa nibs. The cocoa-tree gives two crops of fruit every year

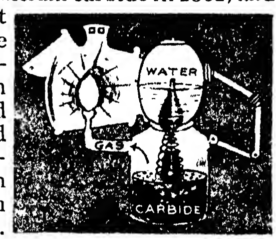
HOW EGGS ARE TESTED

Poultry farmers and egg dealers, of course, have to test the eggs that pass through their hands, and in order to do this they use a specially constructed lamp, like that shown in the picture. The light, which is a strong one, is enclosed in a dark case, the outlet for the light being through a single hole, which has attached to it a very powerful magnifying lens and a funnel-shaped tube. By means of the lens the light is greatly increased, and when an egg is held to the mouth of the funnel, as shown in the picture, an expert can tell at once the condition of the egg—whether it is good or bad, fresh or stale, fertile or unfertile, incubated or not, and, if incubated, whether the chicken inside is alive or dead. When the egg is new laid, an air-space is seen at the large end, but if it has been laid for several days this air-space is filled up. If the egg be stale, it has a more or less mottled appearance. Such egg-testing lamps are quite inexpensive, and every home should have one.



HOW AN ACETYLENE LAMP BURNS

Neither oil nor electricity will give such a brilliant light for a bicycle or motor-car as acetylene, a poisonous gas which was first made from calcium carbide in 1862, and was only brought into practical use in 1892. It is composed of carbon and hydrogen, and is easily obtained by bringing carbide of calcium into contact with ordinary water. This simple process is taken advantage of in the acetylene bicycle lamp, a simplified section of which is given in the picture. The carbide is placed in a receptacle, and a supply of water in a tank above it, so constructed that the water can be turned on or off. When it is on, it filters slowly through on to the carbide, and acetylene gas is at once generated. This passes through a pipe to the burner, where we light it by means of a match. When we want to put the light out, we simply turn the water off, and the stopping of the water stops the manufacture of the gas.

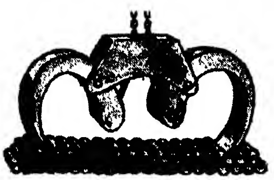


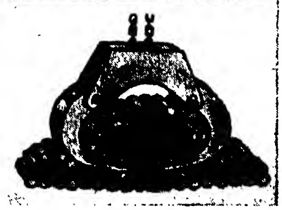
HOW YOUNG TREES ARE PLANTED

THE chief thing to be considered in transplanting young trees is to see that their roots are properly arranged, and for this purpose a hole has to be made in the soil sufficiently deep and wide to take the root without its being cramped. Some trees, like the oak, have a long tap-root with few lateral roots, and the method of planting these is shown in the picture here. By means of a spade, or a similar instrument, a wedge-shaped opening is made, and into this the tree-root is lowered, care being taken that it remains upright and is not doubled up. Then the spade is, in turn, put into the ground on each side, and the soil gently levered back against the root. Where the young tree to be planted has extended lateral roots the planting is more difficult, as a hole large enough to take all these roots in their natural extended position has to be dug, and the tree is then placed in position, and the soil gently shovelled into the opening. Great care has to be taken not to injure the roots.

HOW TIMBER IS UNLOADED FROM BARGES

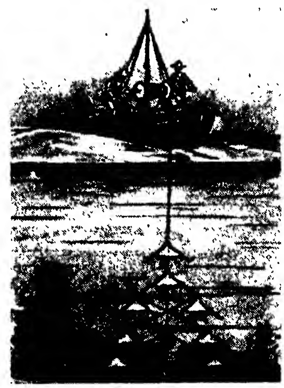
THE principle of the grab, the well-known mechanical appliance used in the unloading and moving of coal, has been adapted to deal with timber, and now, in some ports, barges of timber are unloaded by means of a kind of giant tongs. The timber so dealt with is usually short lengths of about six feet, such as mine-props. The tongs, open, as shown in the first picture, descends upon the load of timber, and then, being closed, as in the second diagram, grabs about fifty props, weighing something like a ton and a half, and holds them firmly while the crane swings them up and out to where they may be wanted. An enormous amount of manual labour is saved in this way, for the mechanical tongs apparatus needs only one man to operate it, and can make about forty grabs an hour. It has proved so successful in the case of short timber that it may very soon be adapted to the unloading of long poles.





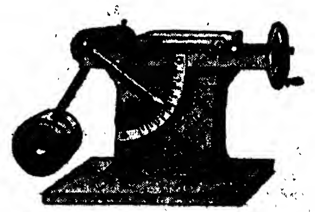
HOW CORAL IS COLLECTED

THE collecting of the red and pink corals from which necklaces and other ornaments are made is a large and important industry in the Mediterranean. The principal fishing-grounds are off the coasts of Algiers, Tunis, Sardinia, Sicily, and the Balearic Isles, and the method of obtaining the coral is quite simple. Men go out in small boats, each having a windlass and rope. At the end of the rope is a series of hooks, usually spread out to cover a considerable space, and when the boat arrives over the coral banks the drag is let down, and the boat then moves along slowly. When it is seen or thought that a good haul has been obtained, the rope is wound up, and the coral which has caught in the hooks is detached.



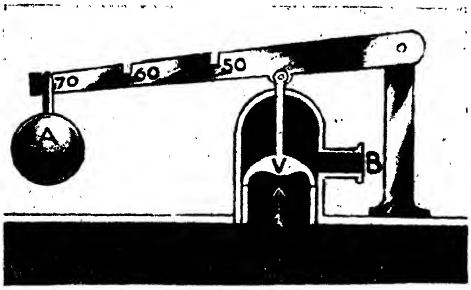
HOW THE STRENGTH OF PAPER IS TESTED

FOR very many purposes it is necessary that paper should be of a certain strength, to stand the stretching or pulling to which it is subjected, and manufacturers and users of paper test the strength of various samples by means of a little instrument known as a paper-tester. This is shown in the picture. A strip of the paper to be tested is fastened into two holders by clamps, and a wheel is then turned by hand to draw these clamps farther and farther from each other. As they move, a connecting wire turns a small hand, or pointer, which indicates on a dial, specially graduated for the purpose, the tensile strength of the particular sample of paper being tested. The pressure on the paper is effected by means of a weight, which gives a much more even and regular test than could be obtained from springs.



HOW A SAFETY VALVE WORKS

PROBABLY all of us know that a steam boiler must have a safety valve, and that the purpose of this is to stop an explosion, but not everyone may know exactly how the valve works. No matter how strong the walls of the boiler may be, they would



burst if the pressure of the steam got beyond a certain point and there were no escape for its superfluous energy. But this the safety valve provides. The valve can be set for various pressures by moving the ball A to different points on the arm. When the pressure approaches the point for which the valve is set—that is, when the steam presses sufficiently strongly to counteract the weight A—it pushes up the valve V, and the steam escapes through B. This goes on until the pressure is again reduced to the point set and the valve closes once more.

HOW A STEEL RAIL IS MADE

IT would probably be impossible to know how many hundreds of thousands of steel rails there are in the world, but when we remember that the railroad tracks exceed 600,000 miles, and that each mile has at least two lines of rails, a large proportion four, and many miles more than four, we can get some idea of the quantity of steel rails in use. If we look at the rails next time we are at a station we shall notice that they bulge out at the top and at the bottom. This peculiar shaping of the rail is effected in the rolling while the metal is white hot. The steel bar is very carefully made,

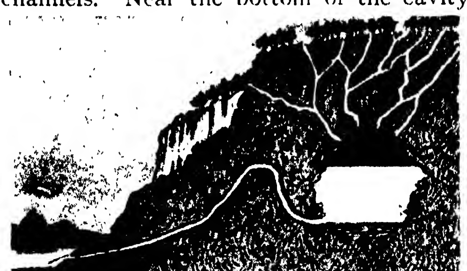
and is then carried by an overhead crane to a cogging-mill, where it is mangled between irregularly shaped rollers until it is formed as we see it on the track. A six-foot ingot of steel is rolled out into two hundred feet of the required shape.

HOW A GARDENER REMOVES PLANTS FROM POTS

TO take a plant from a flower-pot for planting-out purposes is not the easiest thing in the world, as it may look to some people. Unless we know the way to go to work, we are very likely to injure the roots; and if we do so, of course, the plant will almost certainly suffer severely, even if it does not die. The gardener turns the pot upside down, with the stem of the plant between his forefinger and middle finger, and then, very gently shaking the pot to loosen the mould that may be sticking to the sides, he pokes the whole carefully and slowly down with a stick through the hole at the bottom of the pot, as shown in the picture.

HOW AN INTERMITTENT SPRING FLOWS

THERE are many springs about the country which flow for a time, then stop, and after an interval begin to flow again. Springs of this kind are called intermittent springs, the word intermittent coming from two Latin words which mean to interrupt. Somewhere in a hill there is a cavity into which the rain that falls upon the hill finds its way through various channels. Near the bottom of the cavity



is an outlet for the water, which curves upward in its course. As soon as the water in the cavity is up to the level of the bend A the spring begins to flow, and continues until it is at the level B, just as a syphon-pipe empties a vessel of liquid. It now stops, and will not flow again until the rain-water has percolated through the hill into the cavity and raised the level to A once more.

HOW A HOUSE IS MOVED OVER TREES

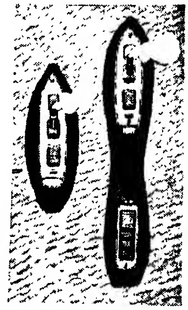
THE Americans are past masters in the art or science of moving houses from one site to another. Not only do they do this when the house, after being packed up on to rollers, can be rolled along the level ground, but they even lift great houses over the tops of the trees so as not to disturb a plantation. Recently Mr. Charles Schwab, the great steel magnate, wanted a house which was quite a large mansion to be thus moved without disturbing some trees that were in the direct line of passage. The engineers jacked the house up to a height of 34 feet, and then moved it over the top of 23 trees across a deep valley to a place a thousand feet or more from its original site, where it now crowns a little hill. Such a task might seem impossible, but the picture shows the house being raised ready for its jump over the trees.

HOW SACKS ARE SENT DOWN A BUILDING

WHEN filled sacks have to be lowered in large numbers from the upper part of a building to the lower, as in a great flour-mill, a rapid and inexpensive method of doing this is absolutely necessary. The plan generally adopted is that of having a special shoot, as shown in the picture. The sacks are placed on the shoot at the top, and no mechanical appliance is needed to bring them down, for, the special roadway being smooth and steep, gravitation does the necessary work. The sacks slide down simply by their own weight. The advantage of such a method where thousands of sacks are being dealt with can be easily understood. The same plan is used for the conveyance of other goods from a height to a lower level, only in the case of boxes and other articles that would be broken by too violent a descent the gradient of the spiral way is made less steep, and rollers on ball-bearings are substituted for the shiny path.

HOW A SHIP USES OIL IN A STORM

SHIPS often pour oil on a troubled sea in order to calm the rough waves, and this has the desired effect, because oil, being a viscous, or slow-moving, liquid, and remaining on the surface of the water, curbs the movement of the waves. The oil is poured into the sea from different parts of the vessel, according to the direction of the wind, the course of the ship, and so on. When the vessel is running before a gale the oil is distributed from the bows, whence it spreads aft and gives protection to the vessel all round, as shown in the first picture. If it were poured on the sea from the stern the oil would, of course, be left behind by the vessel. Where one vessel is towing another in a heavy sea, the towing vessel distributes the oil from its bows and on both sides. In this way the oil spreads so as to benefit both vessels. The oil is distributed sometimes by pipes, and sometimes by throwing overboard porous bags attached to a rope. The oil slowly filters through these bags.



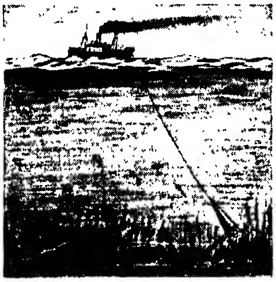
HOW SHIPS ARE LOADED ON A RUGGED COAST

THERE are some coasts which are too rugged for a ship to approach anywhere near the land, and where minerals or other goods have to be shipped regularly the problem of how to load and unload vessels has always been a difficult one. In fact, in some parts of the world rich mineral deposits have had to remain unworked because of the impossibility of shipping them. In recent times, however, the difficulty has been overcome by the erection of what is known as a ropeway—that is, an aerial railway with the cars running on ropes, as shown in the picture. One

such ropeway is working at Thio, New Caledonia, where it conveys valuable ore from an important nickel-mine to ships lying out at sea. Without the ropeway the mine would be quite useless. Probably one day there will be a ropeway at Jaffa, in the Holy Land, where the rocks and surf make landing extremely difficult. It is not only on the coast, however, that these ropeways are used; they are very valuable wherever there is broken country and a mountainous district over which minerals have to be carried from mines.

HOW A BROKEN CABLE IS FISHED UP

When there has been an injury to a submarine cable so that it becomes useless for the transmission of messages, a cable-ship is sent out to repair the line. The method of getting at the cable is interesting. The ship lets down a grapnel consisting of a hollow cone like that seen in the picture, with a number of hooks attached to springs, which keep them out all round the base of the cone. The ship then passes backwards and forwards over the spot where the cable is thought to be, dragging the grappling apparatus with it. If the hooks come in contact with rocks, the springs give, and the hooks go more or less into the hollow cone, but directly a hook grips the cable the pull on the chain or rope holding the grapnel tells those on board the ship that the cable is caught. It is then hauled on board, and the ship goes backwards and forwards examining section after section of the length of cable till the injury is found, when it is repaired, and the cable let down once again.



HOW ORANGE FLOWERS ARE GATHERED FOR SCENT

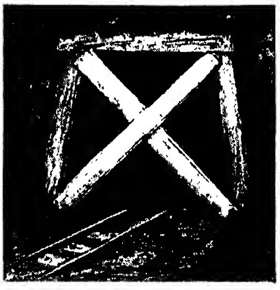
A great deal of scent is made from orange blossom, and the picture shows the way in which the flowers are gathered for the scent factory. Large squares of cloth-like sheets are spread out on the ground under the trees, and the pickers then mount on tall steps, collect the best flowers, and throw them down upon the sheets. The steps, seen in the picture, are not like the steps used in this country, the side opposite to the rungs consisting of a single pole. This enables the steps to be used much more conveniently among the trees than if the kind of steps used for domestic purposes in this country were taken into the orange groves.

HOW A SCAFFOLD-POLE IS LIFTED

It might seem quite a simple matter for two men to raise a scaffold-pole from the ground in order to carry it, but there is a right way to do this, as shown in the picture. The back man picks up his end, and then, when he has raised the pole a foot or so, the first man lifts his end and gets it into position for carrying. Very often, however, builders' labourers, and others who have to carry these long poles, raise them in the wrong way—that is, the front man lifts his end first, and then, when he has it on his shoulder, the back man raises his end. The result is that for a few moments all the weight of the pole (and it is often great) is thrown upon the front man, and, as he has his back to the length of the pole, the weight is liable to pull him over backwards. An accident of this kind, if the pole happened to fall across his leg or arm, might have serious results.

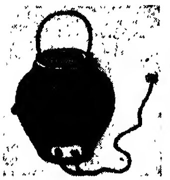
HOW MINERS ARE WARNED UNDERGROUND

Very often it is known that a particular gallery of a coal-mine is dangerous because of an unsafe roof or an accumulation of gas, and the men have to be kept out of it. The usual method of warning them is to place a couple of boards crosswise at the entrance to the gallery, and when they are erected no miner is allowed to pass down the gallery unless specially authorised by the manager to do so. Experts examine the workings and suggest the necessary operations to render them safe, and when these are carried out the planks at the entrance to the danger zone are removed.



HOW GLUE IS MELTED BY ELECTRICITY

The up-to-date carpenter and cabinet-maker has abolished the old-fashioned dirty glue-pot that had to be placed on the fire and came off black and sooty. The latest method of melting glue is to have an electric glue-pot as shown here



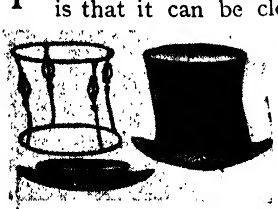
There are, of course, the usual inner pot for the glue itself and the outer one for water, but the heat is obtained by an electric current. There are connections to which a wire can be fixed, the other end being fitted into an ordinary plug in the wall connected with the town or house supply. The liquefaction of the glue is more regular by this method than by the old.

HOW A GRAIN-SHIP IS EMPTIED

The emptying of a ship that brings wheat or any other grain is a simple matter now, compared with what it used to be. Special grain warehouses are fitted with suction plants, and when the ship arrives the hatches are opened and a large nozzle on the end of a flexible pipe is let down into the grain. The engine is then set working, and the grain is sucked up through the pipe and conveyed to whatever floor may be designed as the store for that particular consignment. These pneumatic conveyors are very expensive to intsall, but the saving in labour and time is so great that they pay for themselves over and over again.

HOW AN OPERA HAT IS MADE TO CLOSE UP

The particular feature of an opera hat is that it can be closed up flat and carried under the arm with as little trouble as, say, a gramophone record. In order that this may be done a very special framework is necessary, and what it looks like before the silk or merino covering is put round it can be seen in the picture. The frame is made of steel or some other metal not easily bent or broken, and the upright struts which connect the top and bottom circles have hinged joints which enable the frame to be extended or closed at will. The brim is made of calico specially prepared and stiffened with a solution of shellac. The upper part of the hat is made separately, and the two parts are then sewn together.



HOW BARRELS ARE DRIED AFTER WASHING

Tens of thousands of barrels and hogsheads have to be steamed out or washed in order to clean them for use again, and where this is done on a large scale special arrangements have to be made to dry them quickly. Heat cannot be used, because if this were applied the wood of which the barrels are made would warp, and the casks would shrink and cease to be watertight. An up-to-date method of drying the barrels is shown in the picture. Pipes are laid just beneath the surface of the ground, and smaller upright pipes communicating with the larger main are placed at intervals projecting just above the ground. The wet barrels are then placed in position over these, the upright pipes projecting into the barrels through the bungholes. A dynamo or engine then works a fan fitted at the end of the larger pipe, and this blows a current of high-pressure cool air through the nozzles into each of the barrels. The air carries the damp away through the ends of the barrels, and the continuous stream of cool air soon dries all the moisture out of the casks without injuring them.

HOW GRAPES ARE PRESERVED FOR THE TABLE

We may wonder how it is that grapes can be placed on the table a considerable time after they are cut and yet look as fresh as if they had been newly gathered. At certain seasons many of these come to the British market from the Channel Islands and France, and they are kept in condition by a very simple process When the bunches are cut, a fair-size piece of vine-branch is cut with each, and this is placed in water, and the grapes kept in a temperature of 5 or 6 degrees above treezing point. In these conditions they wlil remain as fresh as if they were still on the vine for quite a long period.

HOW WE GOT THE RAILWAY

There is something so thrilling in moving through space at a great speed that it is no wonder men in all times have sighed for something like Prince Housain's magic carpet, by which they could be transported faster than a horse can gallop or a lion can bound.

David had this longing when he sang "Oh, that I had wings like a dove, for then would I fly away," and the idea so possessed the ancients that the messenger of the gods, Mercury, was always shown with wings attached to his cap and sandals. But, great as was their longing for speed, the ancients could never satisfy it. To rush past the hill and across the plain at a mile a minute remained for them nothing more than a wild dream.

Yet in these days the poorest child can travel faster than Cæsar. We simply step into a train and off we go

Faster than fairies, faster than witches,
Bridges and houses, hedges and ditches;
And charging along like troops in a battle,
All through the meadows and horses and cattle,
All of the sights of the hill and plain
Fly as thick as driving rain.

Every boy and girl knows the delight of the journey. What a thrill it brings as

We charge the tunnels headlong,
The blackness roars and shatters,
We crash between embankments,
The open spins and scatters.

And all this glorious speed we owe to a poor boy who could neither read nor write. George Stephenson was not the inventor of the locomotive, but it was he who made the first safe railway engine. What a strange story it is! The difficulties in the early days of steam travel were no doubt great, but the greatest of them all, one that kept back the locomotive for many years, actually had no existence outside the imagination of its creators. Everybody, even the cleverest engineers, thought that the smooth wheels of a heavy engine would simply go round and round and not grip the smooth rails, and so engineers wasted their time and energy in trying to overcome this difficulty, which did not really exist, and took out all kinds of patents to get over a trouble which was quite imaginary.

They made toothed rails and had cog-wheels on the engine to grip them, but this was unsatisfactory. One such engine was made and put on the toothed track, and crowds gathered to see it steam away. But it would not move an inch, and at last its maker said that either he or she should go. He turned the lever of the safety-valve as far as it would go, and the engine blew to pieces. As a spectator said, "It was the biggest wonder in the world that we were not all blown up."

Another man made an engine that was to walk on legs like a horse, but at its trial the driver overloaded the safety-valve, and the boiler burst, killing a number of people and wounding others.

These incidents, however, did not discourage the engineers. One engine was exhibited in London on a circular track, and used to run races with a horse; and, though we are not told which won, it was probably the horse, for these early engines were not built for great speed. One could drag eight or nine loaded waggons at one mile an hour! The toothed wheels and rails were a great difficulty, and the engine was always getting off the track. When that happened horses were sent to drag the engine home one way and take the trucks another, and at last the railway would break down so often that horses were sent with the engine regularly on its trips, so as to be ready for the breakdown. The driver was one day asked how he was getting on, and he replied, "Getting on? We don't get on—we get off."

George Stephenson, who had now educated himself and was a very clever engineer, took notice of these difficulties and tried to overcome them. He felt sure that the locomotive would supersede all other means of travel, and he

was not long in finding out that smooth wheels *would* grip smooth rails. He made a locomotive which he called the Blucher, and though it was a poor little thing that could hardly jerk along, it showed Stephenson what could be done.

AN ENGLISH RAILWAY WITH DONKEYS INSTEAD OF ENGINES

There were several railways in England at this time, but the trains were drawn by horses or, as in the Surrey Iron Railway between Wandsworth and Croydon, by donkeys. Horses and donkeys were thought a much safer and more sensible means of transport than locomotives, and the editor of a well-known paper wrote: "What person would ever think of paying anything to be conveyed from Hexham to Newcastle in something like a coal-waggon, and to be dragged for the greater part of the distance by a roaring steam-engine?" But Stephenson persevered and convinced a number of able people that he was right, and at last he was appointed engineer to a new railway to be made between Stockton and Darlington. Three of his engines were made, and when the line was opened the first train was preceded by a horseman with a flag. Stephenson, however, soon wanted to put on speed, and called to the rider to get out of the way. To the astonishment of everybody, the train rushed along at the tremendous speed of fifteen miles an hour!

A railway was now talked of between Manchester and Liverpool. Merchants there were crying out for some quicker means of travel than the slow canal, which often took longer to convey goods from Liverpool to Manchester than to bring them from America to England. But there was tremendous opposition to a locomotive railway, and when Stephenson and his assistants tried to survey the land for a route, the Duke of Bridgewater's game-keepers had orders to shoot any of the surveyors found on the duke's land!

MEMBERS OF PARLIAMENT WHO THOUGHT THAT TRAINS WOULD FRIGHTEN COWS

The farmers chased Stephenson's men with pitchforks; the labourers smashed the surveyors' instruments to pieces, although Stephenson had engaged a powerful prize-fighter to defend them. Even a clergyman threatened Stephenson with violence, and his land had to be surveyed secretly, while he was conducting service in his church.

Newspapers and pamphlets published all kinds of curious objections to the railway. It was said the weather would affect the engines, and the wind and rain would stop them dead. One objection was that the chimneys would get red-hot, and that the glare would frighten the cows; but Stephenson, who was questioned on this point before a Parliamentary Committee, asked in reply, "How will the cows know that the funnel is not painted red?"

"Suppose, now," said one of the committeemen, "one of these engines to be going along a railroad at the rate of nine or ten miles an hour, and that a cow were to stray upon the line and get in the way, would not that be a very awkward circumstance?"

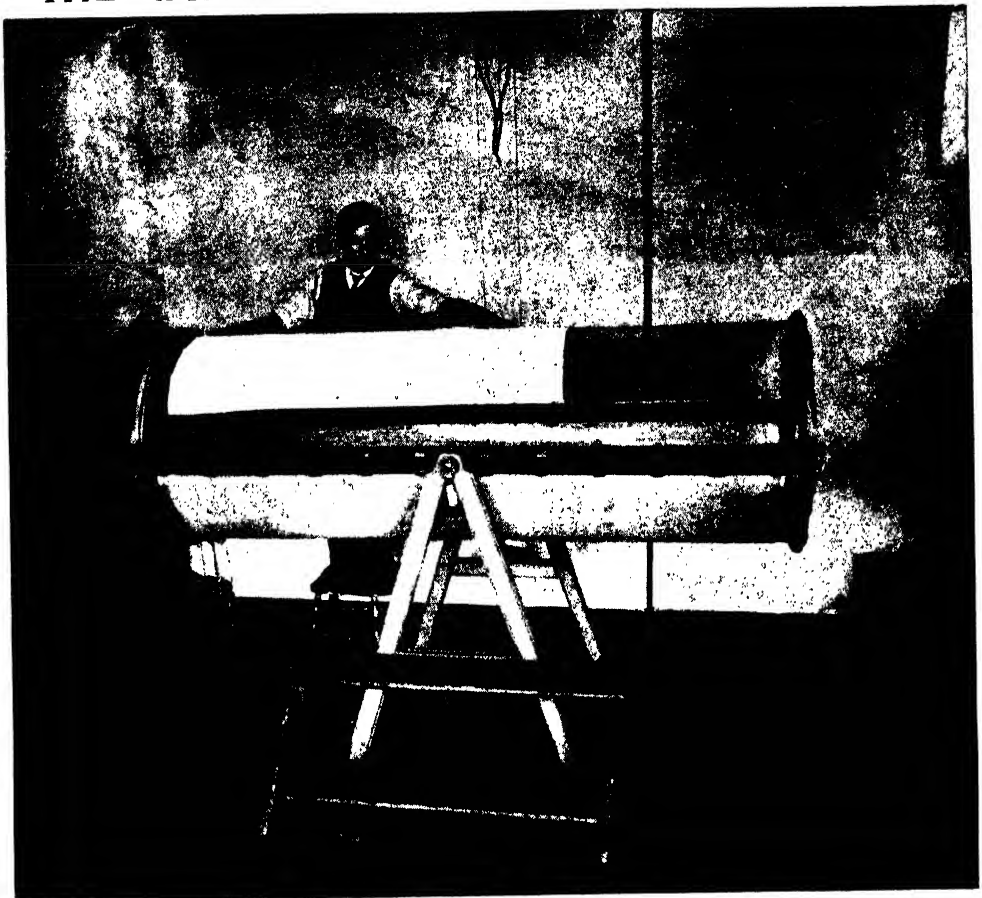
"Yes," answered Stephenson, "very awkward—for the coo!"

Even those who were friendly to Stephenson thought a speed of more than eight or nine miles a wild dream. But Stephenson triumphed. The permission of Parliament was obtained, the route was surveyed, the track was laid, and the Rocket was built—the first really practicable steam locomotive to run on rails. It weighed only seven and a half tons with its tender, but it travelled at thirty miles an hour with a train-load of passengers, and in doing so it revolutionised the world's transport, and did more to advance civilisation than perhaps anything else that has ever been made.

A MIGHTY ENGINE THAT CAN PULL TWO THOUSAND TONS A THOUSAND MILES

That was in 1830, and what strides have been made in the eighty-two years that have passed since then! Now our great express engines, costing nearly £4000 to build, travel at over sixty miles an hour, weigh 140 tons, and can drag a hundred loaded waggons weighing a thousand tons. Round the locomotive and carriage works of the various railway companies have grown up great towns, such as Swindon, which, having a population of only 2500 fifty years ago, now has 45,000, of whom 15,000 are engaged in the Great Western works. Stephenson made his locomotive laboriously, with the aid of a blacksmith and a few crude tools. Now the machinery in a modern locomotive works is worth a fortune, and a great engine can be built in ten hours. In America even greater strides have been made. In that land of enormous distances mammoth locomotives are built weighing 350 tons, nearly fifty times that of the Rocket, and these can pull about two thousand tons, twice as much as our biggest engines, at a high speed maintained for a thousand miles. The magic carpet has come, indeed, and anyone can ride on it to London.

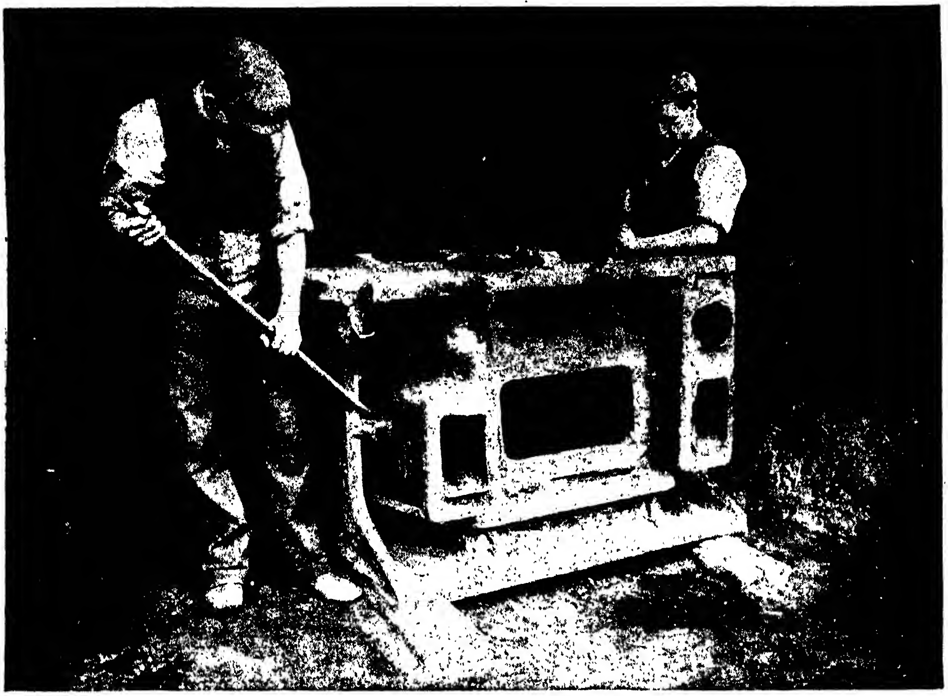
THE RAILWAY ENGINE IS BORN ON PAPER



TAKING LARGE PHOTOGRAPHIC COPIES OF THE ENGINEER'S DESIGNS FOR THE LOCOMOTIVE

PREPARING FULL-SIZE WOODEN MODELS OF THE PARTS OF AN ENGINE. FOR THE BUILDERS TO COPY

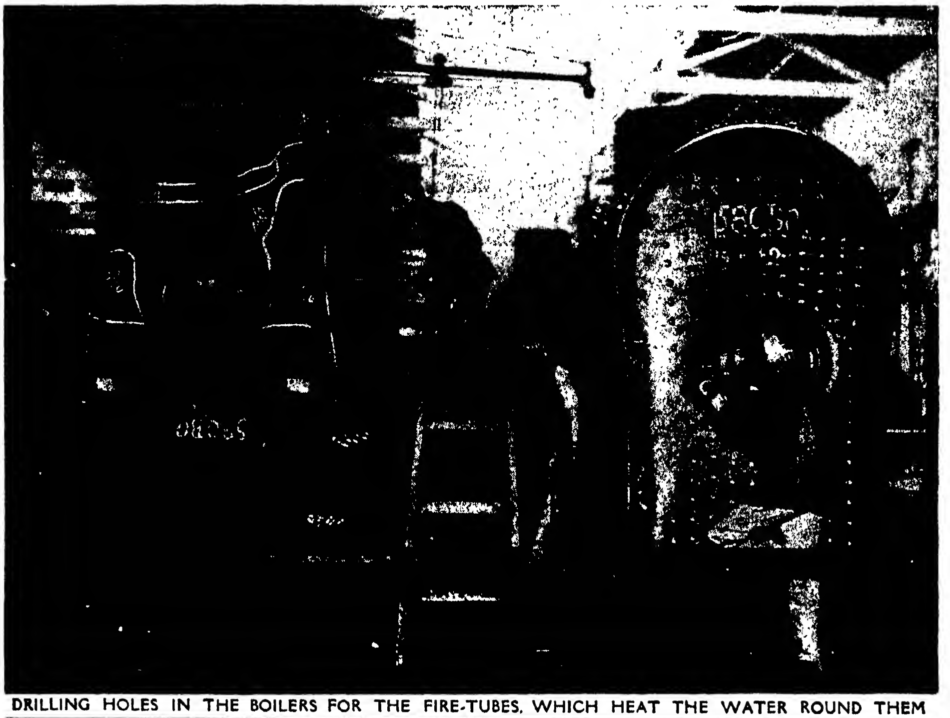
BUILDING UP THE PARTS OF AN ENGINE



CLEANING PART OF THE FRAMEWORK OF AN ENGINE, WHICH HAS BEEN CAST FROM A WOODEN MODEL

FASTENING TOGETHER THE PARTS THAT MAKE THE CRADLE, OR FRAMEWORK, OF A LOCOMOTIVE

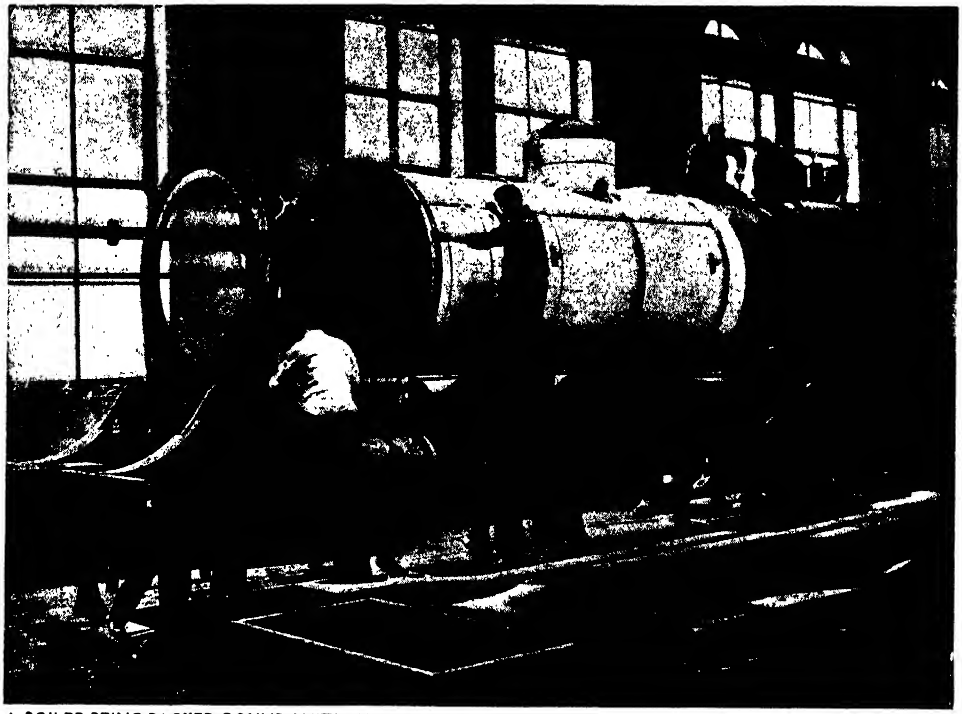
THE GREAT BOILERS THAT DRIVE THE ENGINE



DRILLING HOLES IN THE BOILERS FOR THE FIRE-TUBES, WHICH HEAT THE WATER ROUND THEM

A SILENT DAY IN THE BIG BOILER SHOP OF THE LONDON AND NORTH-WESTERN RAILWAY AT CREWE

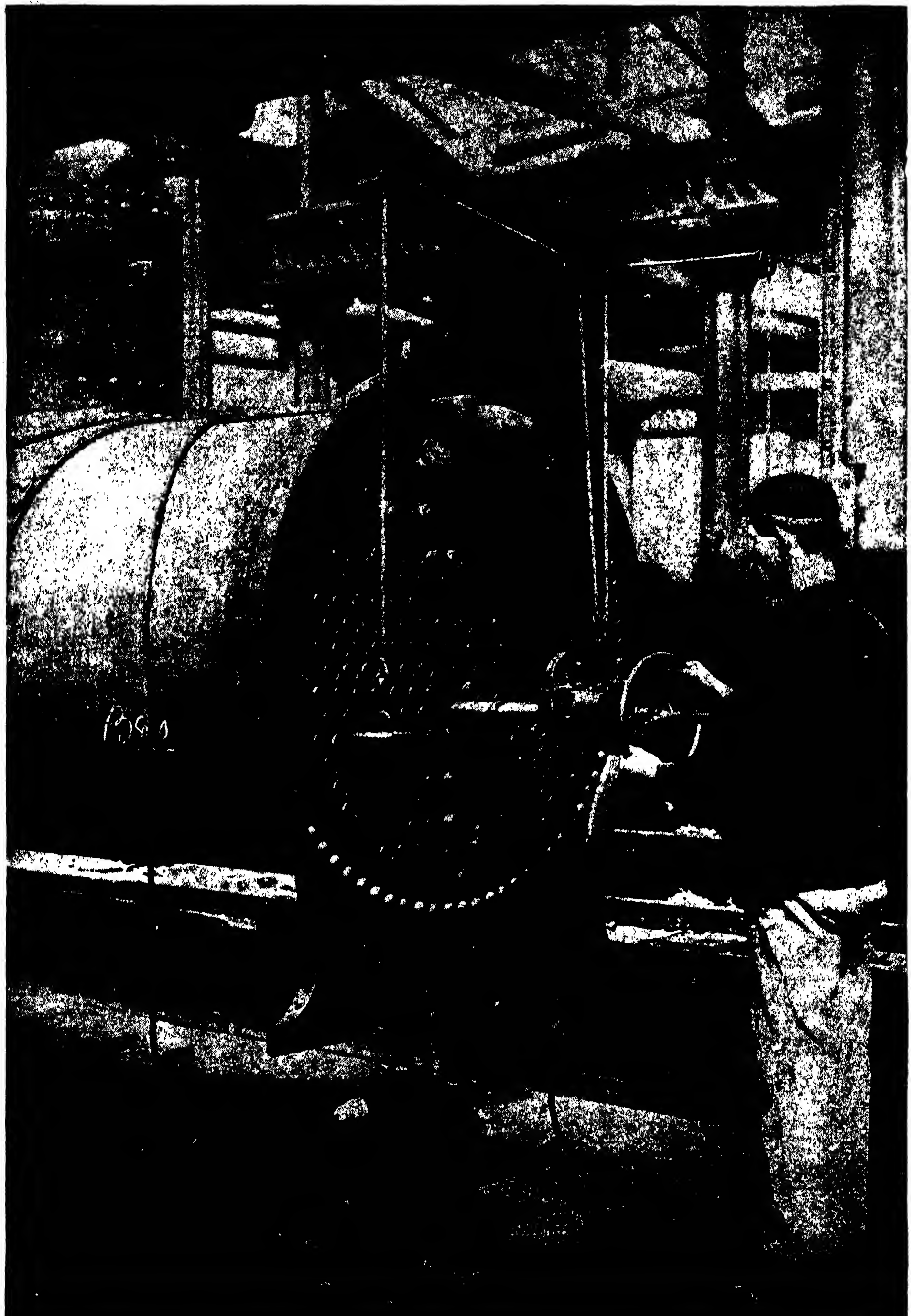
A WARM COAT FOR A STEAM BOILER



A BOILER BEING PACKED ROUND WITH MAGNESIA AND ASBESTOS TO PREVENT HEAT FROM PASSING OUT

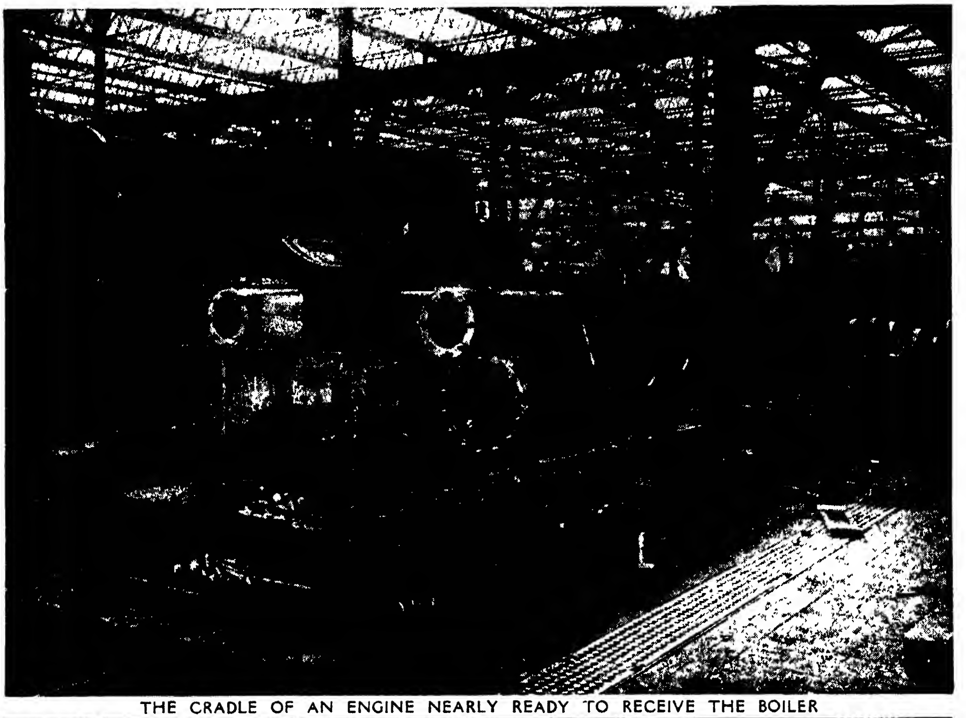
LOCOMOTIVES IN VARIOUS STAGES OF GROWTH

THE FIRE-TUBES THAT TURN WATER INTO STEAM



THE BOILER OF A MODERN LOCOMOTIVE, WHICH IS FULL OF WATER WHEN WORKING, THE FIRE RUNNING THROUGH ITS WHOLE LENGTH IN A NUMBER OF STEEL TUBES, WHICH ARE HERE BEING FITTED

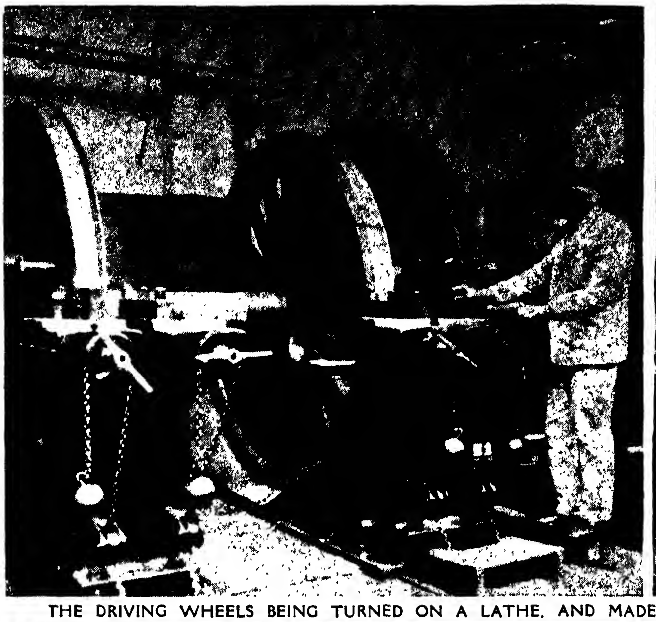
PUTTING A STEAM ENGINE INTO ITS BED



THE CRADLE OF AN ENGINE NEARLY READY TO RECEIVE THE BOILER

THE BOILER PUT INTO ITS STEEL CRADLE

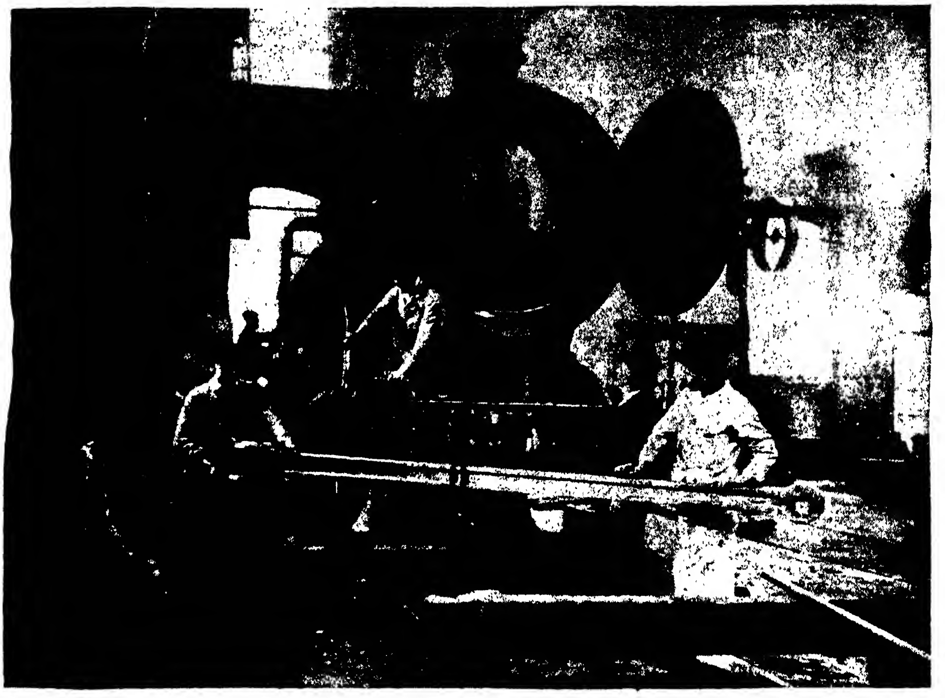
THE WHEELS THAT WILL FLY ROUND ENGLAND



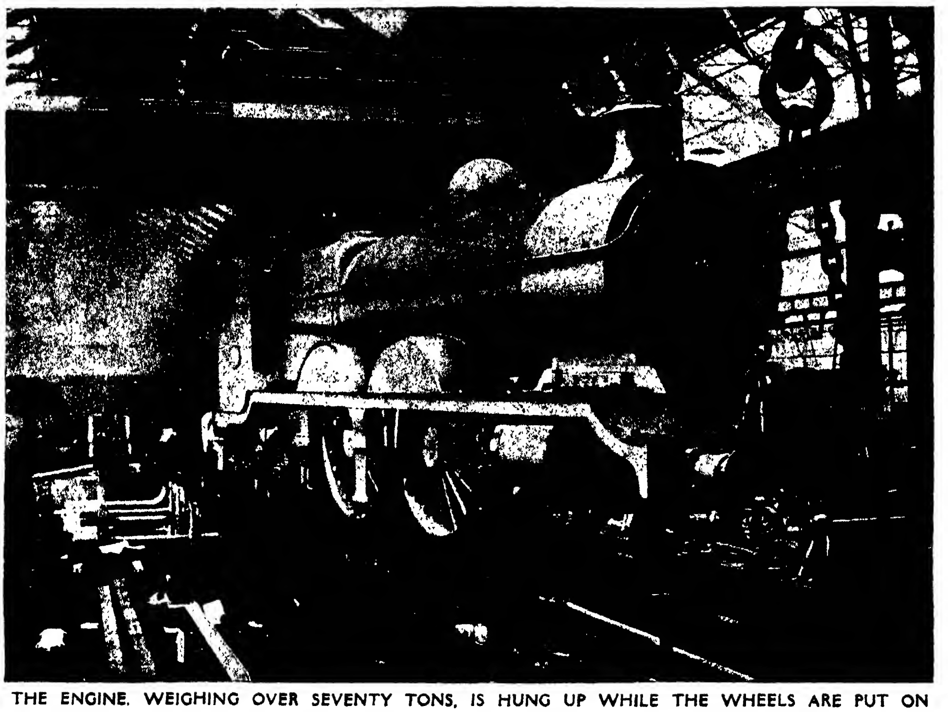
THE DRIVING WHEELS BEING TURNED ON A LATHE, AND MADE READY FOR THE ENGINE

THE WHEELS WAITING FOR THE ENGINE AND THE ENGINE WAITING FOR THE WHEELS

THE PROUD ENGINE IS READY TO SEE THE WORLD



PLACING IN POSITION THE GREAT STEEL CONNECTING ROD THAT TURNS THE WHEELS



THE ENGINE, WEIGHING OVER SEVENTY TONS, IS HUNG UP WHILE THE WHEELS ARE PUT ON

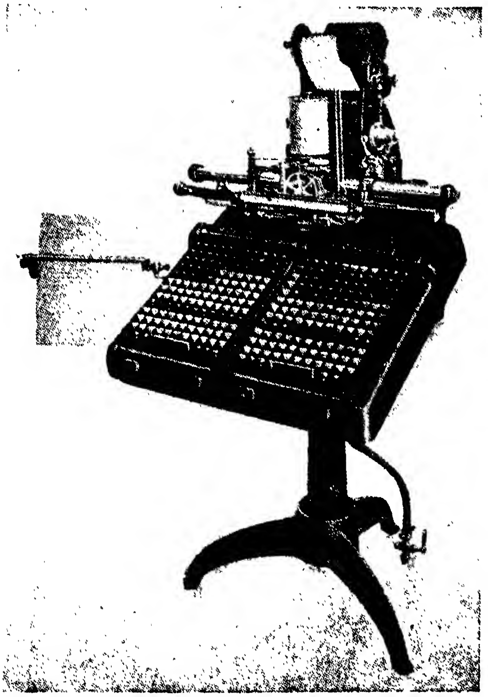
What You Should Know

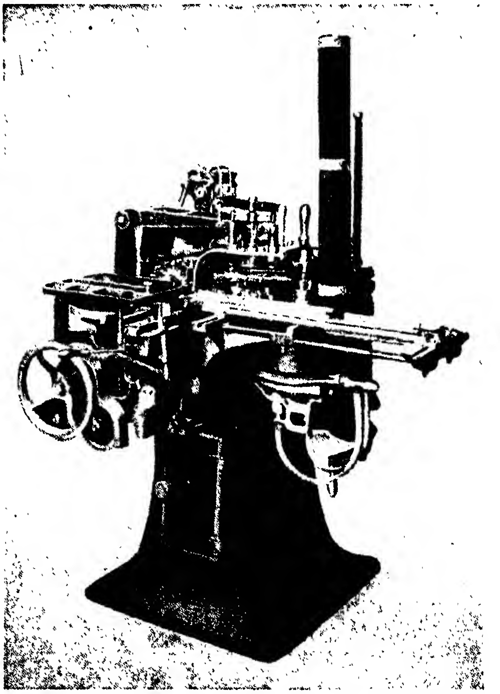
ABOUT THE MONOTYPE

The monotype is the marvellous machine that sets up the Children's Newspaper. It harnesses the air for its purpose. It is a companion of the linotype, the marvellous machine which has already been explained in these pages ; but, while the linotype sets type in a solid metal line, the monotype sets type in single letters.

The machinery of the newspaper world is like a miracle, and in all this wondrous mechanism is nothing more ingenious and intricate than these two machines. As we think back to the days of old William Caxton and his wooden type, the sight of these machines, producing metal types by the thousand before our eyes, putting them into words, spacing them out in lines as if there were something almost human in the metal, is a thing to stagger the mind and impress us with a sense of the amazing progress man has made in these few hundred years.

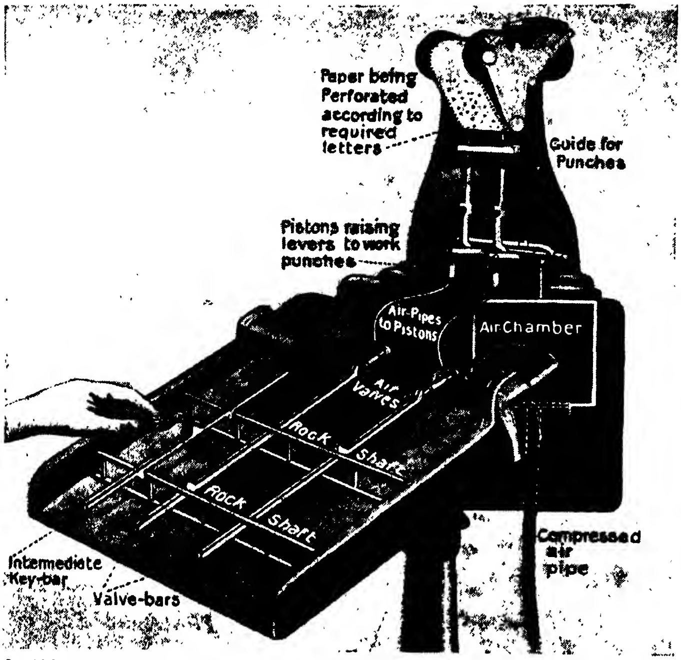
These pictures show how the monotype works. No pictures can show all the intricate mechanism their astonishing movements involve—the levers and valves and tubes and wheels and cranks and cams and keys and cylinders and pistons and rods that guide and control the marvellous work they do—but these pictures will help us to understand something of the way in which the invisible power of air is set to work to produce that wonderful thing that all the world sees every day—the newspaper.





1. THE MONOTYPE IN ITS TWO PARTS. THE MACHINE WITH THE KEYBOARD PUNCHES HOLES IN A ROLL OF PAPER. THE MACHINE ON THE RIGHT TAKES THE ROLL OF PAPER AND CASTS METAL LETTERS IN ACCORDANCE WITH THE HOLES IN IT

1. The machine with a keyboard like a typewriter is the composing part of the monotype. Its business is to perforate the roll of paper with round holes, the position of the hole varying according to the letter struck down on the keyboard. The second machine is known as the caster, and in it the metal types are cast by the ingenious mechanism the following pictures help to explain.



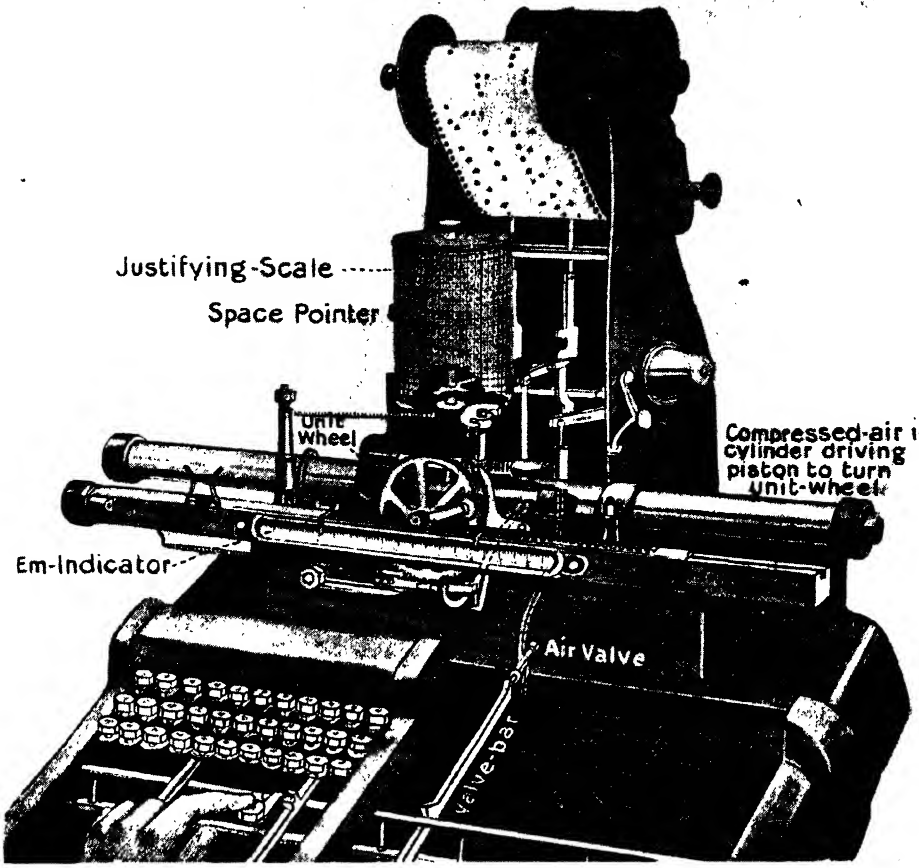
2. HOW THE PRESSING DOWN OF THE KEYS MAKES THE HOLES

After the space is provided for, the second word is punched out in the same way, and that is all that this machine has to do. It gives us a sort of monotype code, which we could quite easily learn to read if it were worth while doing so. It is not worth while, because the caster machine will take these holes and interpret them for us.

2. This picture shows what is under the keyboard, and makes it possible to follow quite easily the way in which the holes are made. As the key is pressed down, what is called the rock-shaft moves. It has a different movement for every letter—that is to say, it moves in one way for the letter M and in another for the letter Y. As it moves it opens the valve which admits air to the little pistons seen just above the air-chamber, and these pistons work levers, which, in turn, work the punches that are to perforate the paper. A special mechanism guides these punches at the same time to the particular point on the paper where the hole must be made, and at that precise point the punch rises and makes the hole. Let us suppose we want to set up the words Children's Newspaper. The first word is pressed out on the keyboard, and then a space-key is pressed down for the space. Each letter and each space is represented by holes in the paper ; often there are two holes for one letter, but every hole made stands either for letters or spacing.

3. What the monotype really does is more astonishing than it seems. If you notice these words as you read them you will realise the general evenness of the spacing between them, and the way in which the monotype manages this is a surprising thing. Let us suppose you are beginning to set a line up on the monotype. You press down the keys for one word, and then a space ; another word and another space ; more words and more spaces ; and then—perhaps your next word has nine letters and you have room left only for three.

What is to be done ? It may not be easy to divide the word, and unless matters can be adjusted the whole line is wasted. What happens is that the machine puts the matter right for you. You will notice how evenly the lines of these columns end. It would not do to have each line ending just where the words happened to reach when they were set up. In that case the ends would be all ragged, and reading books would be a trying thing. What happens on the monotype is that as you near the end of a line a bell rings to warn you that your space is almost gone and must be adjusted. Look at the space-pointer in the picture. This is always rising as you press down the keys, and, when you press down the special pointer-key

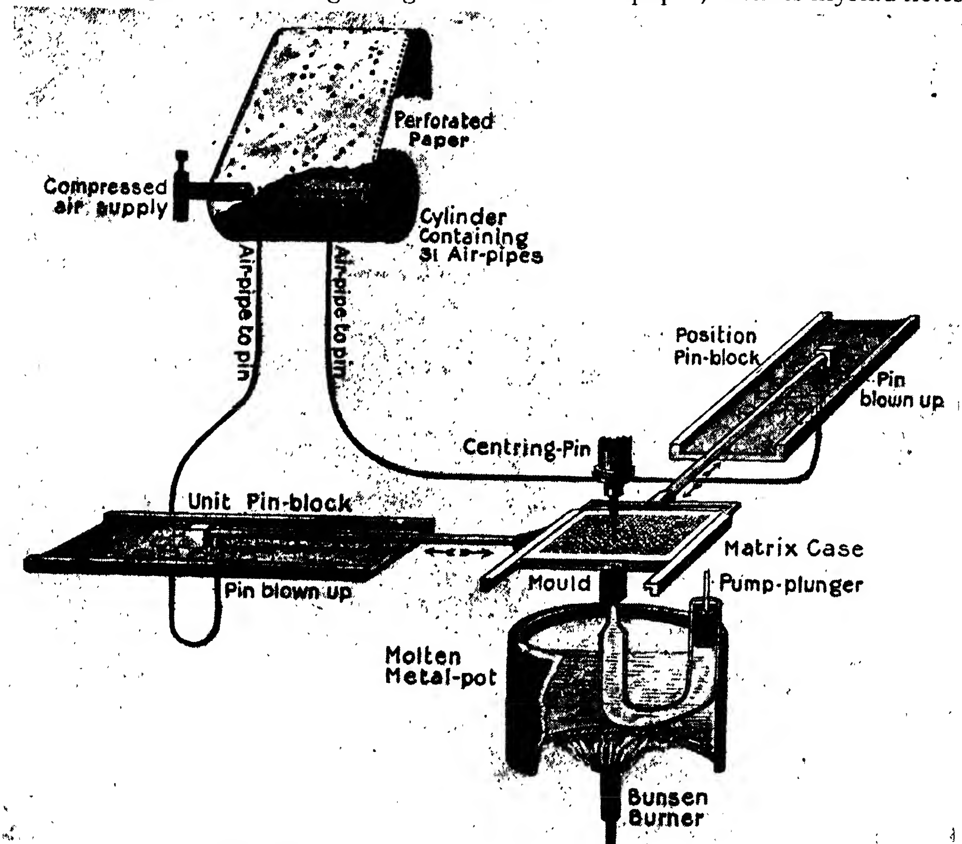


3. THE MARVELLOUS WAY IN WHICH THE MONOTYPE SEEMS TO WORK THINGS OUT

after the warning bell rings, the sort of drum behind the space-pointer—the round cylinder covered with figures, called a justifying scale —swings round so that the pointer touches certain figures, and those figures are precisely the spaces you want.

That is one of the cleverest things that any machine can do, but everything is simple when you understand it. What happens is that the spaces on the monotype are arranged in a series with different widths. There are narrow spaces and wider spaces, and after every word an ordinary space is provided for. After the holes have been punched for a word, the hole will be punched for a space. As the line goes on, the machine registers the number of spaces in it, and when the line is nearly finished, and does not end even, the spacing mechanism comes to the rescue and distributes extra spaces just where they are wanted. If there are six spaces in the line, and it has only room left for twelve thin spaces, it will distribute the space among the six places. It is as if the machine called on the operator to stop, and said to him, " You have not enough room for the next word. Just look at the scale, strike the key the pointer points to, and I will space the line out for you." And it does so. It never puts the spaces in the wrong place, it never drops them in the middle of a word, it puts them where they should be. The bell rings ; the scale flies round till the pointer is at the

right figures; the operator presses the keys with these figures on them; and the little punches punch the holes precisely where they should be. For the extra space at the beginning and ending of a paragraph there is a special key, and the em-indicator tells us how many of these we have or need. Now we will see what happens to this curious roll of paper, with its myriad holes.



4. THE WONDERFUL THING THAT AIR AND METAL AND PAPER DO

4. Here we see what happens in the casting machine of the monotype. The roll of paper is passing over a cylinder filled with air, and leading out of it are a number of little pipes. Only two are shown in this picture. Let us follow them out of the drum. They go to the two pin-blocks, and on each pin-block is a little rod—the matrix-rod. This rod is movable, and its movement is determined by what are called little pins that bob up and down on the pin-block. It is not possible to show the movement exactly here, but we can clearly see the pins blown up inside the block. Now look at the holes in the paper; we remember that they all stand for letters and spaces. So do the little air-pipes inside the air-drum, and there is a pipe for every hole. Running along the drum from end to end is a long line of holes, and behind these holes are the little pipes. Over this drum is fitted the nozzle of the air-valve, so that when the valve is opened the air passes down the little pipes. But it is easy to see that if a sheet of plain paper is passed over this drum the air cannot pass through it, but it is equally easy to see that when one of the holes in the paper passes over the hole in the drum the air will rush down the pipe. That is what does happen.

As the paper slowly winds its way round the drum, the paper-holes pass over the drum-holes one by one, and every time the compressed air is forced down the pipes. It is this rushing down of the air that works the pins in the pin-block, and what happens then is that the matrix-rods move, one this way and one that.

Now we can realise what will happen, for the matrix is full of impressions of letters and spaces, one for every key on the keyboard, and the moving of the rods brings the matrix into such a position that the letter required comes exactly over the little mould above the pot of molten metal. We must remember that what we are doing is to turn the holes in this roll of paper into metal types, and what happens, in a word, is this. Let us say that two holes in the paper stand for the letter M. These holes pass over corresponding holes in the drum, the rushing out of air lifts up the pins and moves the matrix, so that that part of the matrix containing the letter M, cut out in brass, is brought just over the cast mould. Down goes the pump-plunger into the metal-pot, pushing the boiling metal up into the mould. It touches the M in the matrix, and the mould is then closed. When it opens it gives out the letter M in solid metal, and the M glides out and takes its place in a line, waiting for the other letters to join it.

That is the wonder of the monotype, and these machines are doing these wondrous things each day to print the jolly little Children's Newspaper, which tells the story of the world today for the men and women of tomorrow.

WHEELS WITHIN WHEELS IN THE LIFE OF AN ANT

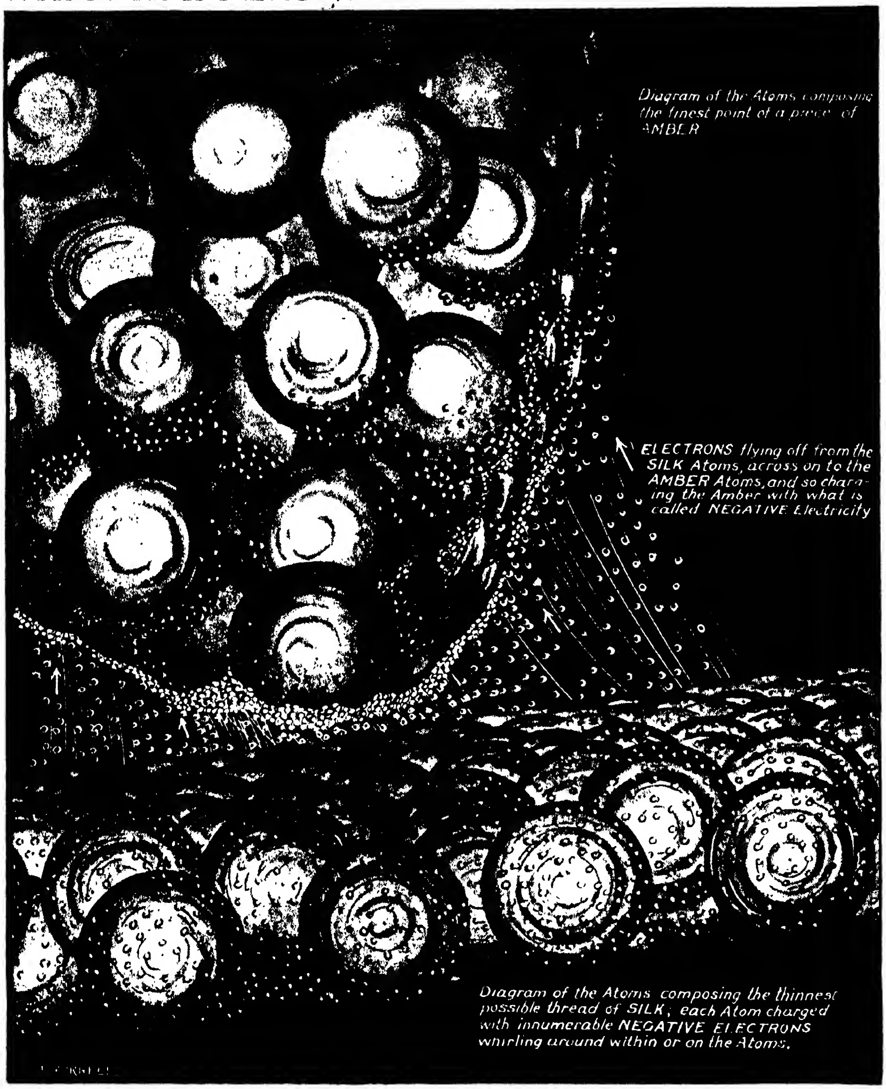
One of the strangest instances of the way in which living creatures get linked up together concerns an ant, a caterpillar, and a tree-bug.

There is in Queensland a small grey moth whose caterpillar begins its life as a hanger-on to a bug which feeds on certain trees, where it is attended and milked by ants. When these ants find the caterpillar hanging on to the tree-bug they take it prisoner and carry it to their nest. But they leave the bug on the tree. In the nest of the ants the caterpillar spins a preliminary cocoon, and emerges later as a peculiar, flat, bright red, second-stage larva, with a long double tail. During this stage it feeds on the young ant-grubs, sucking out their juices, so that it seems at first sight a singularly unprofitable thing for the ants. But the caterpillar emits from time to time drops of an almost transparent liquid, which is greedily imbibed by the ants; and if a thirsty ant is not satisfied with the quantity of elixir it is getting, it will try another caterpillar, or will nip the first one, gripping and pressing the double tail.

When the caterpillar is full grown it is moved by a restless impulse; it seeks a suitable place in which to become a pupa. It leaves the nest, and, attended by some of its hosts, travels to the nearest suitable tree, spins a cocoon in a crevice, and after about twenty days emerges as a small grey moth.

Now, here in England there is a little blue butterfly which lays its eggs on wild thyme and associated plants. The caterpillar feeds on these, and certain ants keep an eye on it, for it has a gland secreting honey which is well worth licking. When the caterpillar crawls to the ground it is captured and carried prisoner to the nest. A curious point is that when the caterpillar meets a suitable ant it hunches up the front of its body, and this has been regarded as a signal to the ant. The evidence points to the conclusion that it is essential for the caterpillar to spend the next chapter of its life-history in the ants' home, where it feeds on their grubs. Why an ant should carry the caterpillar home is difficult to understand, unless simply because of pleasant associations, for we understand that the caterpillar has not been seen to yield the secretion of its honey-gland during its stay in the ants' nest. Is it simply a tolerated guest? We must hear more of this strange story.

WHAT HAPPENS WHEN WE MAKE ELECTRICITY



Electricity, th greatest power in the world, is a mystery that no man can explain. More and more, however, scientists believe that electricity is caused by the movement of tiny particles called electrons, which attach themselves to the atoms that make up all kinds of matter. There are two kinds of electrons—negative and positive, which attract each other but repel their own kind. Atoms are so small that the most powerful microscope will not reveal them, but electrons are hundreds of times smaller still. In this picture the artist shows us what appears to happen when we make electricity in the simplest possible way—by rubbing a piece of amber on silk. The rubbing disturbs the negative electrons of the silk, so that they leap across on to the amber. Here they are piled up, because amber, being what is called a bad conductor, will not let the electrons pass through. But if we hold our finger to the tip of the amber, the electrons jump off the amber to the finger and rush through the atoms of our body, which is a good conductor of electricity, and thus they pass back to the earth, the original home of electrons. If there are enough electrons stored up on the amber, we feel the shock as they leap to our finger. If we hold the amber, with its piled-up negative electrons, against something else that has negative electrons, the amber will push it away; and it is this wonderful power of repelling that makes electricity so useful in the world.

QUESTIONS AND ANSWERS

Why are there so Many Bogs in Ireland?

If you will look carefully at a map of Ireland which shows the mountains, you will notice that they form more or less of a wall round the flatter central land. They are like the rim of a plate. Only on the east side is this not the case. It is partly on account of this peculiar arrangement of the high land and the low land that so much of the country is of a boggy nature. The rainfall in Ireland being very considerable—the mountains of Kerry and Connemara are the wettest portions of the British Isles—an immense amount of water drains into the flat inland, and collects in the lakes and forms numerous bogs. A bog is neither land nor water, but a semi-solid mass of dense vegetation, very dangerous to be caught in. When a bog dries up the mass becomes "peat," which is the main fuel of Ireland, as it is much cheaper than coal.

How Do the Pretty Marks Get Into a Marble?

The various colours which we see in a marble may be either natural or artificial. If they are put there by man, in order to look pretty, the stone is coloured by soaking it first in one solution and then in another, so that the two solutions will act chemically on one another in such a way as to produce the particular colour required. Rich colours, however, often occur naturally in stone, which is highly polished only to add to the beauty of the colours. These natural colours are caused by the way in which the stone has been formed, one layer being deposited on another and differing in colour. The successive layers indicate the action of water or some other agency. All stone which is sedimentary—that is, stone which was formed originally of particles or sediment deposited by water—is apt to show these markings.

Why Don't Ponds and Rivers Freeze Through to the Bottom in Winter?

If rivers did freeze at the bottom they would soon become solid blocks of ice, which would get bigger and bigger as more water came over the ice, so that ultimately there would be no liquid water left. However, it so happens that water has one peculiarity which distinguishes it from other liquids. When heat is added to water just above its freezing-point, the water contracts, instead of expanding like most other fluids. If the temperature is raised higher than four degrees above freezing-point, the water starts to expand again, and the temperature below the surface keeps the water in liquid form, while the expansion of the water in ice form also makes the ice lighter than the water beneath it, so that the ice floats, instead of sinking and choking the river. As the weather gets warmer, the ice, being on the surface, melts, and the river runs freely once more.

Why has a Cat's Eye a Straight Line Across It?

Put down this magazine for a minute and go and look closely at your own eyes in a looking-glass. You will notice that in the middle of each eye there is a dark black hole, *round* in shape. If you look carefully, you will observe that this hole varies in size according to the amount of light at the time, and also according to the distance of the object you are looking at. It can contract to a pin-hole, or expand to about a third of an inch. It is not really black, but simply appears black because it is dark behind it.

This black round hole in your eye is the "pupil." It is not always round. Some animals, especially those which search for their food in the dark, can expand the pupil of their own accord, and cats are examples of this. In cats, instead of a round hole, there is a vertical slit, and this gives the appearance of a straight line across the eye. Some snakes have a similar arrangement. The round hole or straight line is thus a question of the actual shape of the pupil.

When We Stir our Tea, Why Does the Middle of it Sink In?

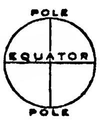
This is a question of the laws of motion and pressure. As long as the tea is left alone it remains still, in accordance with the law of motion which says that all substances at rest remain so until some force is applied to them. Also the pressure in the cup is equal at all points.

Now, when you begin to stir the tea with the circular motion of a spoon, you change these conditions. First you begin moving the tea at the edge of the cup round the margin, causing a current in that circle. The particles which make up the liquid tea are so attracted to each other that you cannot move one part without moving the rest, so that there is a rush of tea to the margin,

where it is rushing round and round. The drawing away of the tea from the central part, and the heaping up of the tea at the margin, leave a depression in the centre, which gets deeper the quicker we stir. We may often see the same thing happening in a river or on the coast, where the water is driven round and round by some current, making a small whirlpool with a hollow in the middle. It is more noticeable, however, when the fluid is enclosed, as in a cup or a pool, where the edges of the cup exert pressure on the sides of the liquid.

How Do We Know that the Earth is Not Quite Round?

THIS interesting fact has been discovered in several ways, some of which are rather complicated, but the main facts are these: We know the earth spins round on its axis, and the points where there is no movement of rotation are called the Poles. The line joining the Poles is called the axis of rotation. Half-way between the Poles is the greatest circumference of the globe, and this line we call the Equator.



Now, if the earth were exactly round, the distance from Pole to Pole would be exactly the same as that from one side of the Equator to the other, but it is not. From Pole to Pole—the polar diameter—is 7900 miles; but the equatorial diameter is 7927 miles.

Besides this, it is found that if similar objects are weighed at the Poles and at the Equator they are found to weigh a little more at the Poles, and this proves that the Poles are a little nearer the centre of gravity than the points on the Equator, which means that the earth must be a little flattened at the Poles.

How Do Men Know When They Come to the North Pole?

TO understand the answer to this question we must know how we get any ideas of direction at all. We speak of travelling east or west, north or south, but how do we get ideas of these directions? We get them from studying the movements of the earth—what is called the rotation, or spinning round, of the earth. The place where the sun rises we call east; the place where it sets we call west—the rising and setting being really due to the earth's going round.

If we stand so that the rising sun is on our right-hand side, and the west on our left, we shall be facing the direction called north, with the south at our backs. The North Pole is the end of the polar diameter of the earth in our hemisphere. The other diameter is called the equatorial diameter—the distance through the earth at the Equator. Now, by calculating the latitude and longitude, men can tell the exact spot at which they have arrived.

What are called the parallels of latitude are circles drawn parallel to the Equator, and are numbered from the Equator, which is called 0, to the Pole, which is 90. Longitude is calculated from the meridian of Greenwich, which is an imaginary line from the Poles through Greenwich. The longitude of the Pole is 0. Now, by means of modern scientific instruments and clever calculations, sailors and explorers can find their latitude and longitude, so that when they find themselves at a spot whose latitude is 90 and whose longitude is 0, it must be one of the Poles. Whether it is the North Pole or the South is shown by the sun's position.

How is the Shape of a Country Found?

IN modern times men have found out wonderful ways of measuring the distance from one place to another, and of fixing the position of any place they want. To find the shape of a country now-a-days, men would take observations which would give them the latitude and longitude of any spot they were in. Latitude, as we know, is the distance north or south of the Equator, longitude is the distance east or west of a line joining the Poles. So all places with the same latitude are exactly the same distance from the Equator. To find the longitude we must always take a given point, like Greenwich, to calculate from, and the imaginary line joining the Poles and going through Greenwich is called the Greenwich meridian. Knowing the shape of the earth, men can divide its surface by lines of latitude and longitude, and by taking observations can find the latitude and longitude of any spot. By marking down on a map a number of these points, they draw a line through them all, and this gives the shape of the country.

How Do Thin Bicycle Spokes Hold Up such Great Weights?

NO doubt we have noticed that wheels of all vehicles which carry weights are either solid or have spokes. Thus our railway wheels are solid, while the wheels of carts, carriages, and cycles have

spokes. On a bicycle there are a great number of spokes, often forty on the back wheel and thirty-two on the front. Like all machines, however simple or complicated, a bicycle is a means of enabling force applied at one point to be transferred to another point. This is in order to overcome gravity or friction or some other resistance. This resistance is what we call weight.

Now, in the bicycle the weight is on the saddle. If there were no arrangement by means of which that weight could be transferred to other points, the wheel itself would have to be made of great strength. But by inserting forty thin spokes of equal length, fixed in the rim and the centre at equal distances from each other, all the weight on the wheel is broken up into lesser parts, so to speak. The pressure is really transferred to the whole circumference of the wheel, and to all the spokes by the arrangement of these in relation to each other. This principle in mechanics, which can be applied in many ways, is of the greatest value in building bridges and other things in which great resistance has to be borne with safety.

Why has the Mediterranean No Tide?

THE rising and falling of the sea-water, which takes place twice every day, and which we call the tides, are caused principally by the attraction of the moon upon the earth, but, to a lesser extent, by the attraction of the sun as well. When both moon and sun act together, we get the highest tides.

But tides are not the same everywhere. Many things cause them to differ in various parts of the world, especially the arrangement of the sea and land in any given place, and also the depth of the sea. The depth causes different degrees of friction. As the sea gets shallower, the water gets heaped up into very high tides, as we see in estuaries like the Severn. Sometimes the tidal wave has to go round a part of land, and does so in two directions. These two currents, meeting on the other side, neutralise each other, so that no tide is felt, as on the Continental side of the North Sea. In the Mediterranean the tide is stopped by the entrance, which acts as a breakwater would act. This sea is therefore almost like an inland lake as far as the tidal rise and fall is concerned. Hardly any tide is felt past the Straits of Gibraltar.

Why Does my Top Spin when I Whip it?

THE spinning top is often taken as a simple illustration of the great laws of motion, and it moves because of those laws, which state, first—if a body be at rest, it will remain so unless compelled by some external force to change its state; second—its change of motion, if already moving, is proportional to the force which causes it, and is in the same direction; third—to every action there is always a contrary and equal reaction, or back action.

The first law is the most important, and is also the simplest. Tops do not spin of their own accord; what is called their "inertia" keeps them still. But if a new force be applied to the top, it moves according to the direction in which that force acts. The force which makes a thing fly round a central point, as a top does, when spinning, is called *centrifugal* force, and this, applied at the circumference, as in whipping, causes it to spin faster. It also moves the top from one spot to another, because the top goes in the direction in which we whipped it.

What we really do when we whip a spinning top is to add two movements to the top—one centrifugal, driving it round its point, and the other a movement which changes its place of spinning.

Why is the Bay of Biscay so Rough?

TWO things are generally concerned in making the sea very rough near land—namely, the wind and the ocean currents. The Bay of Biscay is known to seafaring men all over the world as a very rough bay to cross, and in the old days, before ships were so large, it was much dreaded for its storms and rough seas. Its navigation is difficult because of the north-west wind which prevails.

This sends in large waves from the Atlantic Ocean, and these, striking against the curved coast-line, cause the water to be thrown back into the bay, making it rough. As if this were not enough, there is a current—called Rennel's current, after James Rennel, a famous geographer, who studied its action—which runs round the north coast of Spain from the ocean, and adds to the disturbance of the sea. With high winds blowing the sea in one direction, cliffs causing it to rebound, and a current sending it in a third direction, is it any wonder that the Bay of Biscay is a by-word for seas that are rough?

Why Do Flowers Die so Soon?

We are apt to think of flowers as the whole plant, but that is a mistake. The flower is the most beautiful part of a plant, and the part easiest to see; but it is only part of the plant, made for the special purpose of producing seeds from which new plants will grow. The process of preparing the seeds has been going on long before the flower opens; then, when it does open, it gives the signal, by its beauty or its scent, that all is ready.

Insects promptly visit it, and by carrying to the flower some yellow pollen, which they have got from another flower of the same kind, they make the seed quite ready to grow into a new plant. When this is done, the petals of the flower, which are the beautiful part we see, have no more use; they drop off, and we say that the flower is dead. But this is not death; it is part of the processes of the life of the plant that are going on from generation to generation.

Does the Sun Keep Still?

No. We have perfect proof that the sun moves in two different kinds of ways at least, if not more. For one thing, the sun spins upon itself. This we know because we can watch sun-spots appearing on one side of the sun, travelling across its face, disappearing, and then coming back again after an interval of days.

The sun spins in the same direction as the earth spins, and in the same direction as that in which the earth revolves round the sun. Secondly—and this is far more astonishing and tremendous—we can prove by watching the positions of the stars that the sun is moving through space, and all his family, of course, including ourselves, must be moving with him.

There is a glorious bright star, Vega, one of the whitest and most splendid stars in the sky, which is said to represent about the point toward which the sun and his family are at present moving. The rate of that movement is believed to be about twelve miles a second.

Is it Possible that Monkeys will ever Become Men?

There is no great future for the race of monkeys, simply because they are so far behind to-day that they have lost the race for ever. Hundreds of thousands of years have passed since man became master of the world once and for all. All other creatures are more and more coming under his will, wisely or unwisely. There are four kinds of monkeys that form a special group of their own, and are called man-like.

Two of these exist in the Congo forest, and will probably soon become extinct; the other two live in Malaysia, and their fate, though probably not quite so near at hand, will doubtless be the same. This is a vast pity, but if there were no men on the earth the case would be utterly different. And we, who know that man has been produced from lower forms, cannot deny that monkeys, if they had a chance, might show that same power of getting better, which is the most glorious and endless power in Nature.

Can Insects Communicate with Each Other?

Insects are, perhaps, the most wonderful talkers in the animal world. They make us realise that communication does not depend upon tongue and lips and voice alone. They talk with their feelers, or antennæ, as they are called. There is no doubt about it; we may all witness, if we cannot hear, their conversations.

If the bees in a hive lose their queen, they do not all immediately discover it. The saddening fact becomes known at first only to a few. But these meet others, whose antennæ they touch with their own, and so tell the direful story. These communicate the news to others, and so the news is spread, all by means of this language of the antennæ. Soon the hive is in an uproar.

Very much the same sort of language must be employed by the ants. All their words are spoken by means of their feelers. No one who has watched them at work can doubt that the wonderful cities of the bees and ants are regulated by strict discipline, which is enforced by means of orders given by one section of workers to another.

To see whether the habit of ants of communicating news was to be observed when they were in a state of captivity, Huber, the great naturalist, placed a large number of them in a closed and darkened chamber. At first the ants scattered in much disorder. By-and-by an ant discovered a way out of the darkened chamber. He returned to his companions and touched several of them with his antennæ. Soon all the ants assembled in lines, and marched out with

one impulse, the desire for liberty, to be gained as communicated by this most wonderful of all the ways in which talk is carried on in the animal world.

Do Birds Talk to One Another?

There can be little doubt that birds have an extensive language, but not all of it that we hear is important; some birds chatter for the love of hearing themselves, and we are all glad that they do. But they have their important talks, and we know positively that it is serious language which they use. Men who devote the greater part of their leisure to the study of birds and their calls can deceive birds by imitating those calls. Men get to know that certain calls are followed by certain results, so, hiding themselves on the shore or in the fens, they utter these cries, and birds, wild and nervous as only wild birds can be, will drop from the clouds to answer the call, which they imagine to be made by some bird of their own species. Fowls afford a good opportunity of studying bird language.

We may note the language of the hen when she has laid an egg; when she warns her chickens of danger; when she calls them to rest under her wings; when she calls them to food. We may note, also, how the male bird sounds his defiance; how he gives a warning; how he cries out a signal which means "hark!" when he hears a strange sound.

Do Ants Catch Slaves as Men Used to Do?

There is not the slightest doubt that ants do catch slaves, and that they hunt for slaves in parties.

When the slave-making ants desire to plunder some prosperous home of the ants called Formica fusca, they do not all wander off, aimlessly searching. No; for weeks they have properly organised parties of scouts and spies going out every day, searching the country far and near. These scouts return at night and present their reports; for the general mass of the ants never go out until the spies bring news of nests to be plundered.

When such a nest has been discovered, the slave-hunters sally forth in a body to rob it. Generally the march to the nest is well ordered, but in the rush for plunder some confusion may arise, and the long procession may be broken up.

Then groups of the party of slave-hunters will lose their way. As soon as this happens, scouts will be sent out by the lost ones. The whole party of the latter will remain perfectly still until the scouts have scented out the trail. These scouts return to their friends and tell them the news. Then they set forth again on the trail, and march on to the nest to join in stealing the infants of the nest, whose home is thus broken up.

If We Can Lift Things, are We Stronger than the Pull of the Earth?

If we can lift a thing, certainly we are stronger than the pull of the earth *for that thing*; and when we cannot lift a thing, it is because we are less strong than the pull of the earth for that thing.

The force of gravitation depends in an absolutely regular way upon the amount of matter in question. A small stone is pulled upon by the earth to a certain extent with a certain force, which is not very great, though the earth is large. For though the earth is large the stone is small, and the force of gravitation depends upon the size of the two things in question. But if the stone be a great rock, then the force of gravitation is proportionately greater, and we cannot lift it.

Why Does a Kite Keep Still at a Great Height?

As you read this you may be looking out across a sea-bay. Here and there along the coast you may see the water being disturbed in small patches by the gusts of wind blowing off the shore.

Farther out to sea the water is all in the same state, not patchy. This means that the wind near the shore is blowing in little bits at a time, and if you were in a small boat you would feel it quite strong at one moment and not at all a few yards farther on. If you were flying a kite close to the ground, it would dive unsteadily in these small gusts, but far out at sea it would fly quite steadily. So it would if it got high up in the air.

The reason is that the surface of the ground is very uneven, broken up by hills and valleys and trees and houses and bays and promontories, round all of which the gusts blow at intervals. This is why boating is dangerous on lakes and in similar places; and the same thing accounts for some of the accidents which happen to airships. Flying men prefer to be at a great height, because, like the kite, their aeroplane goes more steadily high up than near the surface of the earth.

WHAT DOES SOWING WILD OATS MEAN?

In the North, the Danes call the heavy vapours which steam from the earth just before the season of vegetation Loki's Wild Oats; when the fine weather comes they say: "Loki has sown his wild oats." Loki is the evil being of the North.

We might ask ourselves if this is the origin of the phrase about a foolish and extravagant young man "sowing his wild oats." Perhaps it is; but there is something very interesting to be learned about real wild oats. It is said that if we take a head of these wild oats in a moistened state, and lay it carefully on a table, the next morning we shall find that it has moved some distance away. It is like a rolling stone.

We must not imagine, however, that there is anything magical in this power of wild oats to move about. The spike of these oats is exceedingly hard, and does not "give," like the ordinary spike of oats and barley; and so it comes about that the weight of the ears overbalances these sharp-pointed spikes, and the head of corn goes tumbling and rolling over and over, like a stupid young man who cannot settle down to good steady work.

DO OUR EYES MAGNIFY?

The real meaning of the word magnify is to make bigger, and if we remember this, we must see at once that our eyes do not magnify. When we look up and see the sun or moon or a star, we are looking at a thing so huge that our bodies are nothing at all compared with it, and the image of that thing upon the curtain at the back of our eyes is tiny compared with our bodies.

If we think of an eye, and the size of it, and then think of the fullest possible extent of the curtain at the back of it, and if we then think what a great expanse of the world may be figured upon that curtain we shall understand that, of course, our eyes do not magnify. A thing magnifies when it makes the image of an object bigger than that object itself. A microscope does that. It may take a thing so tiny that our eyes unaided cannot see it, and yet throw on our eyes an image as large, perhaps, as that thrown by the sun when we look up into the sky. In such a case it is not our eyes that have done the magnifying.

Many insects have eyes which are of a quite different pattern from our eyes, and which, so far as we can judge from the structure of them, look as if they must really magnify. If they are to do so, they must be used as a microscope is, with the lens—whether a piece of a glass or a part of a living eye—extremely close to the object that is to be looked at. If we use our own eyes for objects placed so near as that, we cannot see anything at all, for our eyes are not made for that kind of vision, but are really meant for use at considerable distances, that being the use which costs them least strain and tires them least.

WHAT ARE SUN-SPOTS?

Sun-spots were first seen by Galileo, in 1609, over 300 years ago. These dark spots, seen by a little glass, have now been examined not only by huge telescopes, but also by having the light from them studied separately in other ways. It has been found in America, during the last four or five years, exactly what sun-spots are.

They are a sort of magnetic storm in the gases that make the atmosphere of the sun; and they twirl as they move, just like the storms that we can study in our own atmosphere, the air. Those in one half of the sun always twist in the opposite direction from those in the other half of the sun—as is the case also with movements of the air upon our own earth.

The light from sun-spots, when examined, is found to have been affected by a special kind of force called magnetism; and that is one reason why we know that sun-spots are really a sort of magnetic storm of a special kind in the sun's atmosphere.

Magnets on the earth are affected by sun-spots, as it appears; and it may be that there is also a close connection, if we could trace it, between sun-spots and our weather—or, perhaps, not so much the weather as it is from day to day, as the climate over several years. We know that sun-spots regularly increase and decrease in number every eleven years.

But we must not say, as is usually said, that the sun-spots move the magnet needles on the earth, or change the weather. Whatever is the cause of sun-spots—perhaps something not in the sun at all—causes at one and the same time sun-spots on the sun and magnetic disturbances on the earth.

ARE THE BEST SPEAKERS THE BEST THINKERS?

Certainly not, though we are too apt to suppose so. A thinker cannot be a thinker except in words, and the words in which he thinks must certainly be capable of being either spoken or written, but it by no means follows that the thinker will be able to speak well. So much depends upon external circumstances. One man really thinks his best, whatever that is, when he is aroused by facing an audience; another can only think his best when he is absolutely alone with a pen in his hand. Good writers are often not good speakers. One of the greatest poets that England has produced since Wordsworth was the dullest and most uninteresting talker that could be imagined, and his friends say that they cannot remember a single noteworthy thing that he ever said. Yet, when he had a pen in his hand, he wrote some things which will never be forgotten. Oliver Goldsmith was another such case, for it was said of him that "he wrote like an angel and talked like poor Poll." On the other hand, many wonderful and effective speakers have been poor writers, and when their speeches are taken down and printed we find, on reading them in cold blood, that there is nothing in them. Indeed, the power to speak well really argues nothing for or against a man's thinking power; and it is a good thing, on the whole, that nowadays the written word is so much more important than the spoken word, for it is much less apt to mislead us.

DO WE CHANGE OUR BODIES EVERY SEVEN YEARS?

There is no foundation at all for the notion that we change our bodies "every seven years." Almost every part of our bodies, except the outside of the teeth and part of the bones, is changing slowly all the time, for the material of it is being worn and burnt away and replaced by new material. That is one of the reasons why we have to eat. In a very true sense, we "die daily," and build ourselves up again from our food. If it were possible to mark all the atoms in our food and all the atoms that make our bodies, we should certainly find that nearly all the material of the body changed completely in far less than seven years. But seven was an old magic number, and in most superstitions where numbers are concerned, seven comes in.

It is often asked why, if we change our bodies so often, marks in the skin remain. The reason is that the form of the body remains, though the material of it comes and goes. The stuff that makes our brain-cells flows into them and out of them, but we still remember things that happened to us perhaps half a century ago.

On the other hand, there are certain parts of the body which are simply made somewhere else, and pushed out or pushed up to serve for a little and then disappear. Hairs are like this; people who dye the hair soon find that they must renew the dye every now and then, for, as the hair grows, the real colour begins to show at the roots. The same is true of the outer skin, which is made and pushed up by the inner skin. Marks and stains on the outer skin do not stay, for the cells are soon washed away, and are replaced by new ones from beneath. But marks in the "true skin" remain, and never disappear from it.

WHY DOES A CANNON-BALL BOUNCE OUT OF THE SEA BEFORE IT SINKS?

What happens to the cannon-ball when it bounces is what happens when we make "ducks and drakes" with flat stones as we walk along the seashore. The key to it is the key to all cases where anything bounces. The moving object has force in it, for motion is a kind of force. When it strikes against anything, like a ball thrown against a wall, part or all of its force is changed into something else. The shape of the ball, or whatever it be, is changed, and it is thrown into a state of strain.

What will now happen depends entirely on the nature of the moving object. If it is made of sand or snow, gathered into a loose ball by our hands, the force of its motion is changed into a force that scatters the parts of the ball asunder, as we notice when we throw a snowball at anything.

The reason is that a ball of snow or sand has no elasticity. But an india-rubber ball or a cannon-ball has elasticity, which means that when it is knocked out of shape it tends to return to that shape, unlike the snowball, and this return makes it rebound from the surface it has struck. The cannon-ball cannot rebound for ever from the water, although it remains elastic, for neither the water nor the ball is perfectly elastic, and soon gravitation has its way, and the ball sinks into the sea for the last time.

IS IMPURE AIR LIGHTER THAN PURE AIR?

We are apt to be rather misled on this point, for other things affect the weight of air besides the kind of stuff that is in it; and one of the most important of these things is its temperature. It is true that in a room or church or theatre the impure air is lighter than the pure air, and therefore it ascends. But though this is true, and though every architect and everyone at all responsible for the ventilation of buildings or shops should know it, yet it is not true that impure air is really lighter than pure air. The impure air made by human beings or animals, or by fires, gas-jets, lamps, or candles, is hot because it is all made by the process of burning, or combustion, whether inside our bodies or outside them, and that process produces heat. Now, the hotter the air is, the lighter it is.

But if we were to wait until this impure air had cooled we should find that the impure part of it was really heavier than the air in general. The most important gas in impure air is carbonic acid gas, and this is heavier than ordinary air, always assuming that it is of the same temperature. Thus, in caves and mines and other places where carbonic acid gas is formed, it always tends to lie as low as possible. This is a fact which every miner knows; and it is a very interesting experiment to lower a lamp down an old mine, or a well, or a deep hole in the ground, and find that when it has dropped a certain distance it goes out because it has reached the level of the carbonic acid, which is a gas already burnt, and so cannot support the burning of anything else.

DOES CHANGE GO ON IN OTHER WORLDS?

We know from our study of the surface of the earth that in the course of long ages it changes very much indeed. But men have always been inclined to suppose that the skies do not show any change except merely in the position of their inhabitants. However, when we study the sun and the planets by means of powerful telescopes, we find that all sorts of slow changes are going on in the heavenly bodies, just as on our own earth, which is, of course, one of the heavenly bodies. Perhaps sun-spots need not be counted, as they come and go, and no one can say that there is any evidence of any changes in the sun going on steadily in one direction, though doubtless such changes are going on. But there is no doubt as to changes in at least two planets, Jupiter and Mars.

On the surface of Jupiter, the giant planet, there is a curious marking called the great red spot; and during the years that this has been watched it has certainly shown changes in shape and size and colour. They are, indeed, much quicker than the changes on the earth that happen at the present time; but the surface of Jupiter is much hotter than the surface of the earth, which has mostly become set and rigid, while on Jupiter the surface is much more fluid, and, indeed, so hot that it probably gives out some light of its own still. As for Mars, it shows many changes both in large features and in small. Considerable areas of Mars, which must once have been ocean-beds, are now certainly dry. That is not a change which men have actually seen, but changes of other kinds have actually been watched.

WHY DOES YEAST MAKE BREAD RISE AND BISCUITS BUBBLE?

Yeast is a simple kind of living plant which produces a substance called a ferment, that has the power of causing certain chemical changes in sugar. When yeast is used to make bread, the results all follow from the fermentation of sugar by the ferment which has been made in the living cells of the yeast. Sugar is an extremely complicated substance, containing three kinds of atoms—carbon, hydrogen, and oxygen. When it is fermented, what really happens is that the sugar is partly burnt—that is to say, the ferment takes a certain amount of oxygen from the air and adds it to the sugar, which is decomposed, as we say, and turned into something else. If anything made of carbon, hydrogen, and oxygen is completely burnt, the result will be carbonic acid from the burning of the carbon, and water from the burning of the hydrogen. In this case the burning is not complete, but still a good deal of carbonic acid gas is formed, and this makes the bubbles which form in the dough, and cause it to rise. A good deal of it escapes into the air, but much is caught, as the baker wishes, and so the bread is made.

The other thing which results from the fermentation of the sugar is alcohol,

which is also a compound, though a much simpler one, of carbon and hydrogen and oxygen. For this reason the process we have been describing is usually known as the alcoholic fermentation of sugar. Practically the whole of the alcohol flies away into the air and is lost. This is a pity, for alcohol is a very useful fuel, and it should be caught in some way whenever bread is being made.

WHAT IS THE DIFFERENCE BETWEEN A FRUIT AND A VEGETABLE?

In ordinary talk we usually make a distinction between fruit and vegetables, but most people could scarcely say what the difference really is, and certainly everyone should know that all fruits are vegetable, even if we do not call them "vegetables." All living creatures are divided into two great classes, animal and vegetable, and every kind of fruit belongs to the class of vegetables.

Still, though an apple or a strawberry is just as much a vegetable as a cabbage or a potato, we can find a distinction between them. Indeed, students of vegetables or plants use the word fruit in quite a definite way. Many kinds of plants do not produce a fruit at all, but all the higher plants do, even including the greatest trees. The fruit of a plant is that part of it which contains the seed. Indeed, the fruit and the plant exist in order to produce the seed; when we study the history of the fruit we find that it always comes from the flower. The purpose of the flower is to form the seed, and to allow it to be prepared for its future purpose; and then the flower disappears and we have, instead, the fruit, which holds the seed for its destiny—which is to be planted in the ground.

Thus some of the things that we usually call "vegetables," such as tomatoes and cucumbers, are fruits in the proper sense of the word, because they bear the seed.

COULD A MACHINE GO ON FOR EVER?

This is a new way of asking the old question whether men can find what is called "perpetual motion," though that phrase is the worst in the world to express what is meant. The whole universe is a perpetual-motion machine. In the nineteenth century many men thought they saw signs that the universe is running down, like a clock that was once wound up, and that in time all motion will end. But men see now that when motion disappears it has been turned into something else, and that the motion can be got out of it again. Therefore we believe that all motion is perpetual, for motion is a kind of power, and no power is ever lost, though it may be changed.

When we say that perpetual motion is impossible, we mean something very different. We mean that we cannot get work from power and still have the power which did the work for us. It is never possible to get something for nothing. If a spring is to drive a clock it must get less tight, and then it will need winding again. The power put into it when the clock was wound has gone in the motion of the clock, and perpetual motion is impossible, in the sense that we cannot spend power of any kind and at the same time keep it.

But this is not true of the world of love and kindness and wisdom. *There* it is possible to spend and to keep, to scatter open-handed and to treasure up.

WHAT IS GREEDINESS?

People often say that children are greedy, and should be ashamed of themselves. Now, children, and grown-up people too, may often be very hungry, and then will eat a great deal and perhaps very quickly. The question is whether there is any difference between being greedy and being very hungry. There is a difference, and a very real one. When we see anyone eating dry bread, however much or ravenously he eats, we do not say that he is greedy, but we simply say that he must have been starved, and is very hungry.

We say that a child is greedy when he wants to go on eating, not because he is hungry, but because he likes the taste of highly flavoured food like sweets and cake and rich Christmas pudding and crystallised fruits. This is not hunger at all, for a child or a grown-up person may greedily eat far too much of such things just after a good meal.

This is really the craving of the nerves of taste, and that is an utterly different thing from hunger. Therefore it should have a separate name, and we are right to call it greed, and to regard it as unworthy when people do not control themselves in this way. Some grown-up people are often just as greedy as children, though usually not so much for sweets as for other highly flavoured foods

Why Does a Red Sky Mean a Fine To-morrow?

UNTIL we know a great deal more than we do about the things that happen in the air, no one can answer such a question as this. In all matters of knowledge there are two stages, which are quite different from each other. Often we do not get as far as the first stage; oftener still we cannot get beyond it. The first stage is when we notice, and the second is when we understand. There are special names given by philosophers to these two kinds of knowledge—the first, which just comes from experience, they call *empirical*, a word that comes from a Greek word meaning experienced; and the second, which depends on our reason, they call *rational*

Nearly all our knowledge about the weather still belongs to the first stage. We have gone so far as to notice "that a red sky at night is the shepherd's delight, and a red sky in the morning is the shepherd's warning." These facts would probably be first noticed by shepherds themselves, or other people who lived under the sky and were bound to watch it. Men's minds are largely filled with this kind of knowledge, and very useful it is as far as it goes.

But this question demands the higher kind of knowledge, which we call rational. It is not merely, Does a red sky at night mean anything for the morrow?—but, *Why* does it? All we can say is that the electrical state of the air which is favourable to a red sunset is also unfavourable towards making rain.

Are New Stars Being Formed Every Day?

WE must certainly believe that new stars are always being formed, and it is very likely that, if we could survey the entire universe of stars, far beyond the reach of our most piercing telescopes, we should find that new stars were being formed at quite as fast an average rate as one every day. This would be only an average, of course, for sometimes more and sometimes fewer stars would be formed in any given period of time, according to the laws of chance.

But, indeed, we should find some difficulty in answering this question if we looked closely at the making of the stars, for we should find that this is a very gradual process, and that no one could say exactly when a new star had been formed. Stars are made by the coming together and shrinkage of great masses of glowing gas which are called *nebulæ*—because they look like distant clouds, when they are seen in the telescope. The Latin word nebula means mist.

Now, there is scarcely any particular moment at which we can say that what was till then a nebula has now become a star. What we can say is this: A nebula, wholly made of gas, gives out a particular kind of light, as we learn when we look at it through a prism. Later, when part of the nebula becomes solid, the character of the light changes; and perhaps at that moment we might say that a star—or a number of stars, as is often the case—had formed in the nebula.

Why Does the Sky Not Get Filled Up with Smoke?

WE can put the question in another way, and ask what becomes of the smoke which our chimneys pour into the sky. It is a question which can only be answered by asking, first, what this smoke consists of. It is mostly made up of solid particles of carbon, and also of a variety of gases.

The wind is constantly carrying smoke away from cities, and scattering it through the air far away, so that it becomes much less noticeable. The smoke from great eruptions of volcanoes may be carried all round the world, and make the sunsets much more beautiful in consequence, thousands of miles away, many months later.

But in course of time many of the heavier particles settle by their own weight, and so return to the soil. The gardeners at Kew could tell us a good deal, for instance, about what happens to the smoke of London, and you may be sure they do not like it at all. Indeed, Kew Gardens would have been ruined if the smoke of London had continued to be as bad as it used to be. We all know how smoke gathers from the air on trees and buildings.

Some of the gases in the smoke are burnt up, and so got rid of; but a great and precious agent, which keeps the air sweet and pure, and is always at work washing the dirt out of it, is the rain, and everyone knows how pure and clear the air is after a shower. Every raindrop leaves a clean track of air behind it as it falls to earth.

What You Should Know

ABOUT A STEAM-ENGINE

No man has seen a thunderbolt, for earth has no such thing, but every man has seen a thunder-bird, for it flies through your homeland every night. A mighty, thrilling, unforgetable thing is this thunder-bird, sweeping through the kingdoms of this world as if it possessed the earth—and possessing it, too.

It is the railway train, this great engine of power that rushes past us in the dark, with its fiery furnace and perhaps its thousand lives. See it set out from London on some wild and blustering night, with the wind howling about its windows and the rain beating down ; the thunder-bird cares nothing for the weather. It leaves on the minute, it will arrive on the minute, and those people who step on the train in London will step out in Glasgow or Aberdeen, safe and sound, and no worse because they have travelled with the thunder-bird for hundreds of miles in about as many hundreds of minutes.

He will take you where you want to go. Join him in Paris and he will take you to Rome. Take him in New York and you can ride to San Francisco. He will take you across Australia. You can join him at the Atlantic and ride on his back till you see the Pacific. You can take him in sight of the Pyramids and he will deliver you in the Holy Land. He will carry you for days and days, sleeping or waking ; across rivers and ravines, up the Alps and down again, above the earth and under the earth and through the golden desert.

And yet the magic of the thunder-bird is all in a drop of water. How little you think of it as you stand and look into some placid lake, or watch the goldfish in the pond, or see the raindrops trickling from a tree, or see a tear fall from some mother's eye on some sad day ! Yet all this power of steam that drives our mills and factories and engines comes from the oldest, simplest thing in all the world—a drop of water. It was here before the earth itself. Without it the earth could never have been a place for you and me. For inside a drop of water is the miracle of power, the atom of gas that will do for man the work he cannot do with his own hands. You would think it strange if some mysterious wizard should wave his hand across a pool and bring out of it the power of a million horses, but it happens every day without the wizard. We light a fire and make the water so hot that the atoms of gas fly for their lives, and in flying they hit against an iron door *and move it.*

That is the magic of the thunder-bird—as simple as Nature, but too wonderful for human understanding. Let us see how it works ; let us take the very simplest engine we can find that goes by steam. It will help us to understand the principle at work in all these other engines—the thunder-bird that flies across the Continent, the engines that plough through the seas, and all those hundreds of kinds of engines great and small. One and all, they began with a fire and a drop of water, as we see in these pictures.

1. THE STEAM-BOILER WHICH SEPARATES THE GAS FROM THE WATER

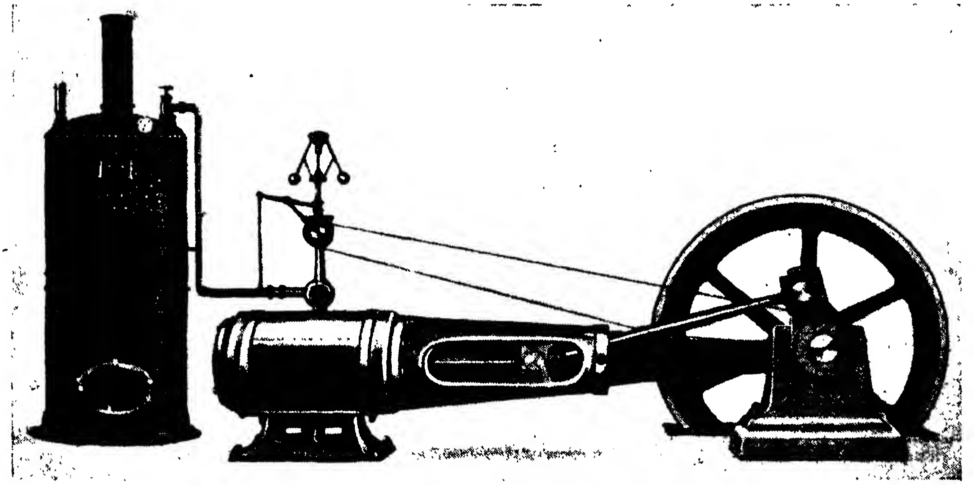
1. We fire a gun by turning a solid into a gas ; we drive a steam-engine by turning a liquid into a gas. One thing we must be quite clear about : steam is simply gas, and what we

usually call steam is not steam at all. When the kettle boils on the fire, what escapes through the spout is the vapour containing the steam, and the steam itself is invisible.

We have to think of three aspects of water when we think of a steam-boiler like this. First there is the water that pours into the boiler. The fire heats it until it reaches boiling-point, by which we mean the point of heat at which the gas escapes. The gas is carried off in the vapour that we see escaping when the water boils. We may say that this is the water thinning out, and flying off because the heat of the fire has expanded it until it is lighter than air. Imprisoned in this vapour are the molecules of gas, powerful but invisible. We may say that it is the water thinned out to its last possible degree.

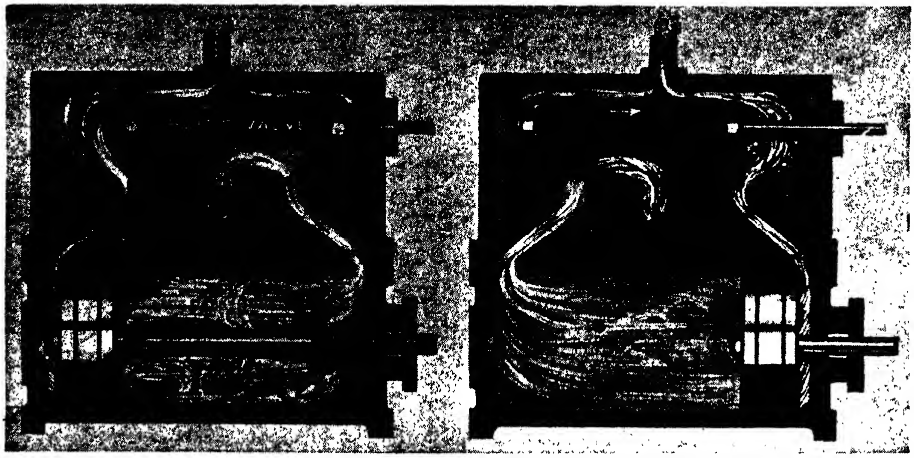
What happens in a boiler, therefore, is this. The water is running all round in the shell which encloses the fire ; it runs everywhere it can get, in the space all round about the fire and often through pipes criss-crossing into the fire, as seen here. The nearer the water can get to the fire the better. The heat expands the water, which means that the water, as it gets hotter, is always thinning out or becoming less dense, as we say. The water nearest the fire is, of course, hotter than the rest, and at last part of the water is so hot that it spreads out enormously and cannot be contained in the space it occupied before. Water turned to steam must find 1600 times the room it occupied before, and must find it instantly.

You have often burst a puff-ball and seen it spread itself like a cloud of dust in the air. What a moment before was in a space as big as a marble is now filling a space as big as a drum. It is the same with water as it grows hotter , and at what we call boiling-point the water expands so that it must find more room. It flies off in the form of vapour, carrying with it the powerful atoms of gas. When the kettle boils, these atoms fly into space and are lost, but if you could collect them in a box they would soon be powerful enough to burst the sides of a box, or if a kettle had no spout and the lid was locked they would burst the kettle into bits. What a steam-engine does is to draw these atoms of gas into itself through an iron pipe, like the small pipe on the right of the picture on page 325.



2. THE ENGINE WHICH CAPTURES THE ATOMS OF STEAM-GAS THAT FLY OUT OF THE BOILER AND USES THEM TO TURN THE WHEELS

2. The atoms of gas generated in the boiler must seek an outlet somewhere or the boiler will burst, and the only outlet they can find is the pipe leading from the top of the boiler to the engine. Through this pipe the steam rapidly makes its way into the cylinder, as we see in this picture, and inside the cylinder it drives the piston which makes the wheels go round. In this picture the piston is hidden, but we shall see it in a moment. Here we see the piston-rod, with the rod that connects it to the big fly-wheel, and we see, working from this wheel, the cylinder cord controlling the governor—the two beautifully balanced balls immediately above the cylinder. Simple as this engine is—the simplest form of engine we can have—it is wonderful in the smoothness of its working and the rhythmic balance maintained by all its parts.



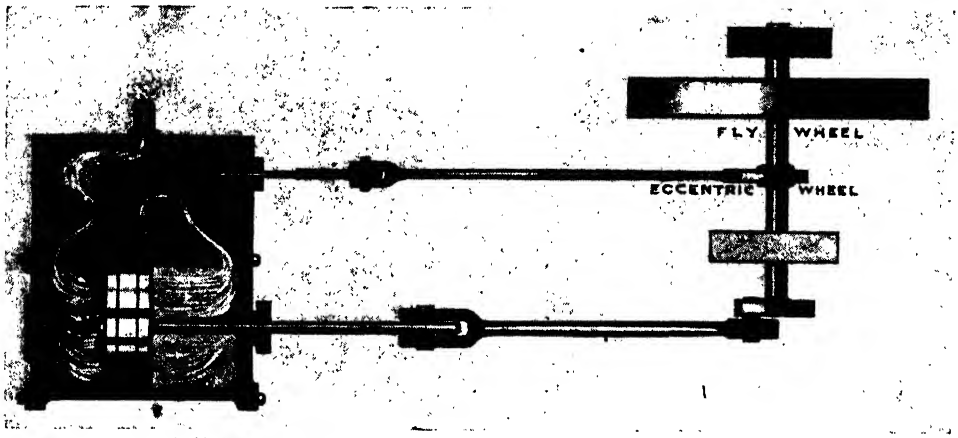
3. THE SLIDING DOORS OF THE CYLINDER THAT SHUT AND OPEN HUNDREDS OF TIMES A MINUTE TO LET THE STEAM-GAS IN AND OUT

3. From the boiler the gas rushes through the pipe into the steam-chest of the engine. Here we see it on its way right to the piston-chamber. It must go where it can, and there is only one way for it. It flies to the cylinder till it touches the piston, and here these mighty atoms bombard the steel disc so hard that the disc flies back to the other end of the cylinder. A situation like that must have baffled the first man who made an engine. Something must keep the piston going. What is to happen now? The piston can go no farther, but the gas is rushing in from the boiler and will soon be here, and unless something moves the whole cylinder must burst.

What happens is that the engine does a very clever thing. The piston, in flying back, carries the connecting-rod with it, of course, and we shall see in a moment how this machinery works. It is all so ingeniously arranged that, as the piston-rod flies back, another rod flies forward. The cylinder doors are fixed to this other rod, and as the piston goes back the sliding door goes forward, so that the door by which the steam came in is shut. No more steam can come that way. But as this door shuts another opens, and through this open door the gas pours in to drive the piston on again. Let us call these doors the front door and the back. They shut and open hundreds of times a minute. The front door opens, the steam rushes through and drives the piston on; then the front door shuts and the back door opens, and the steam through the back door drives the piston again.

No wizard's chest was ever more wonderful than this steam-chest of an engine. Inside it is the secret of every engine that works by steam-gas. The ingenuity of its mechanism is well worth studying closely, and these pictures and the picture following make it all quite plain. We see the steam arriving with its full power, we see it do its work, and we see the piston it drives driving out the steam in turn when its work is done. Notice how the doors work to admit the steam both ways, in and out. Not only do the doors shut and open with lightning rapidity and with marvellous precision, but as the piston flies to and fro it clears the cylinder of the used-up gases, driving them into the exhaust-box. We see the process going on in these two pictures. As the piston drives back it forces out the used-up gas that drove it forward—it drives the gas through the little black hole just under the sliding valve.

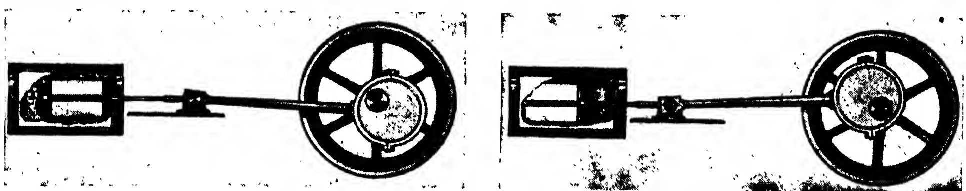
Look at the left-hand door in both pictures. In the first picture it is open, in the second it is shut, but in shutting the door into the cylinder the sliding valve opens the door into the exhaust-box. That is to say, when the door is shut so that steam cannot enter, it is still open for steam to go out. We may say that steam comes in at the front door and goes out at the back, or else comes in at the back door and goes out at the front. Through one door or the other the steam reaches the piston all the time, it moves the piston forward either way, and when the piston needs the gas no more it drives it out through the black hole of the exhaust-box.



4. HOW THE WONDER-BOX OF A STEAM-ENGINE IS CONTROLLED

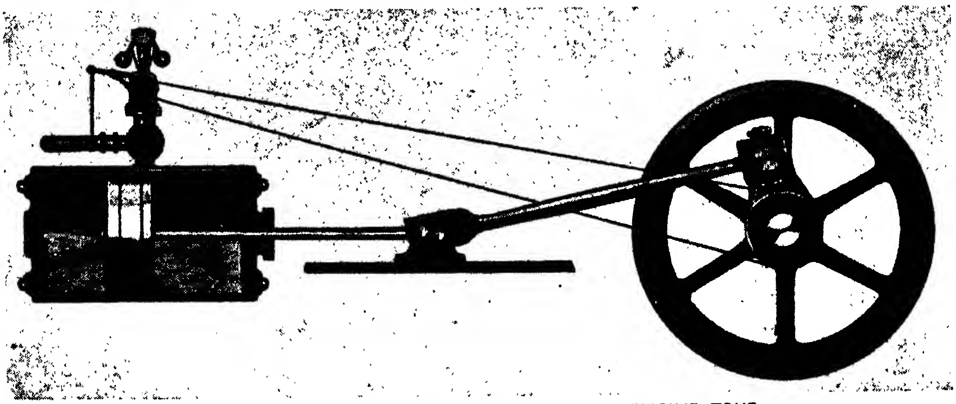
4. Here, looking down on the steam-engine, we see how the marvellous exactness of its movements are obtained. We see the steam rushing in and driving the piston through the cylinder. The piston-rod, of course, flies with it. The piston-rod is joined to the connecting-rod, which joins the crank of the main shaft, so that, as the piston-rod flies to and fro, the shaft goes round and round. In the middle of the shaft is what is called an eccentric wheel—called eccentric because the centre of the wheel is not the centre of the shaft. The result of this is that the wheel does not run true, but has a kind of wobbling motion. The wobble affects the moving of the eccentric rod, which is joined by another rod to the sliding valve.

Now we see what happens. As the piston flies forward the eccentric wheel drives the sliding valve backward, shutting the door and cutting off the steam. As the piston comes one way the eccentric wheel drives the sliding valve the other way—that is to say, it admits the steam just when it is wanted and where it is wanted. In this picture the piston is moving towards our right, and when it reaches the right hand of the cylinder the left door of the cylinder will be closed and the right door will be opened. As the piston moves to the right the sliding valve moves to the left. It is right—left, right—left with these two all the time, and upon this perfect sympathy the working of the engine depends.



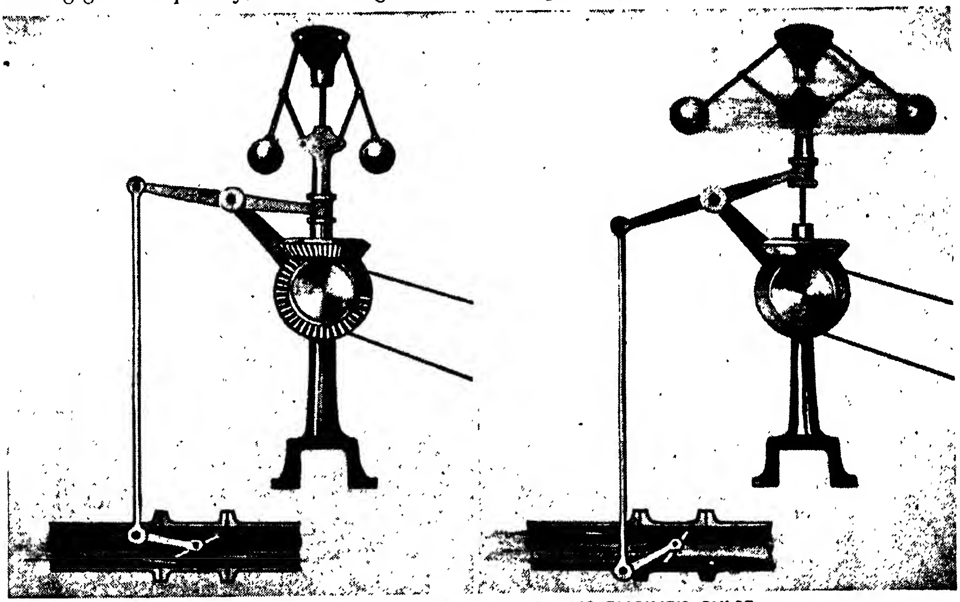
5. THE ECCENTRIC WHEEL THAT OPENS AND SHUTS THE DOORS

5. Here we see the eccentric wheel which wobbles out of its centre, and we see also a side view of the sliding valve, or the sliding doors, as we have called them. As the crank-shaft revolves the eccentric wheel spins round, and its rod, connected with the rod of the sliding valve, moves this valve to and fro. These two pictures show how, with the eccentric wheel in one position, the left-hand door is open and the right-hand closed, while with the wheel reversed the right-hand door is open and the left-hand closed. It is by the working of this eccentric wheel that the shutting and opening of these doors is ingeniously maintained. Remember that a door shut against steam coming in is open for steam going out, so that what happens is like this. As the front door lets steam in, the back door lets steam out; as the back door lets steam in, the front door lets steam out. The steam works the piston, the piston works the shaft, the shaft works the eccentric wheel, and the eccentric wheel works the sliding doors. That is the "round and round" of a steam-engine, going on faster than we can count.



6. THE TWO LITTLE BALLS THAT KEEP THE ENGINE TRUE

6. No man has ever yet been born who could regulate the heat of a fire with the preciseness of arithmetic. We can keep a fire within bounds, but nobody can keep a fire burning so exactly that the heat of a boiler is always just the same. Now, every engine is made to go at a certain speed, and clearly there must be some effective control of the quantity of steam that rushes into it. If the fire is too hot the boiler will be making gas too quickly, and the engine will receive too much power. The engine will race, as we say. It will go too fast with too much steam, or too slow with too little steam. This picture shows what is called the governor, the little instrument with the hanging balls. It is connected with the main shaft by means of a cord, and is made to revolve by two cog-wheels just below the balls. The faster the main shaft goes round, the faster these cog-wheels and the spinning balls revolve.



7. HOW THE SPINNING BALLS FEEL THE ENGINE'S PULSE

7. These two pictures show one of the most wonderful pieces of mechanism on any engine. It is like the "sense" of the engine—certainly we may call it the sensitiveness. Look at the first picture first. The pipe at the bottom is the steam-pipe through which the gas rushes to the cylinder. It rushes past a tiny throttle-valve, which is open in the left-hand picture, so that the steam passes through. In the right-hand

No man needs a keener eye, a clearer brain, and a steadier hand than the driver of a great modern locomotive. Often he has the lives of a thousand people in his keeping, and the least slip on his part may hurl them to instant destruction. The photograph shows this engine dashing along at sixty miles an hour, while the fireman is maintaining the furnace at full heat and the driver is keeping a keen look-out ahead to see that the line is quite clear and safe.

picture this valve is nearly closed, so that very little steam can pass. When the engine is going too fast this throttle closes itself and cuts off steam ; when it is going too slow the throttle opens and lets in more steam. How does the throttle work ?

It is all done by the two balls. We all remember the roundabouts on which we used to ride at country fairs. The faster they went the farther out the horses swung and the higher they were in the air. So it is with a ball on a piece of string. Spin it round and round, and the faster you spin it the higher it will rise. Look at the balls in the left-hand picture—they are still and low down. Now look at the right-hand picture—they are spinning round as fast as they can go. As they spin they rise, and as they rise they pull up with them the rod that connects them with the throttle, so that the throttle works with the balls, shutting off steam when the balls are at their highest, admitting more steam when the balls slow down.

It is the most delicate piece of mechanism that an engine has. It is nearer to the human mind than anything else in an engine. May we not almost call it a sort of intelligence, for it takes the place of a man ?

HOW THE COUNTRIES GOT THEIR NAMES

A COMICALLY stupid person had been having his first lesson in astronomy, and at the end of it he scratched his head in wonder and amazement. "What beats me," he said, "is to know how men first learned the names of all the stars."

He imagined that every star calls itself by some name, and that atronomers had, in some way, learned these names. Of course, the names by which we know the stars are only the names by which men have agreed to call them. When a builder makes a new street, he has to give it a name; and when an astronomer discovers a star he has to call it by some name by which it shall be known. Continents and countries, towns and counties, oceans, seas, rivers, and lakes came by their names in the same way.

THE NAMES OF THE CONTINENTS

Some of the existing names are very old, and in those old names we often find, when we examine them, meanings which tell us what old-time people thought of the lands and waters which they named. A great number of names of places mentioned in the Bible and in ancient history have died out, and their places have been taken by new names. Empires and cities have vanished from the face of the earth, and their records live only in books. It is interesting to glance at some of the names now in existence and to find their hidden meanings. First let us take the continents, the five great land systems into which the earth is divided.

AFRICA. We get the name of Africa, "The Dark Continent," from two words. One is Phœnician, *afri*, meaning a black man, and the other is the Sanskrit *ac*, meaning country, so that Africa means really "country of the black man."

AMERICA. When Columbus discovered America, the continent had no name. He thought that he had reached a western part of India, so he called the islands in the Carribbean Sea the West Indies. The people he called Indians, and to this day the natives of America are called Red Indians. The name America came from Amerigo Vespucci, a traveller from Florence, who visited the country a year after Columbus. The name America was not used to describe the New World in the days of Columbus or Vespucci.

ASIA. The oldest continent known to man is Asia. It is supposed that man first made his appearance on the earth in Asia, and spread from there into the other parts of the world. "Asia" is the modern name for this continent, and comes from the Sanskrit word *Ushas*, which means "land of the dawn," a very good name for what was probably the birthplace of the human race.

AUSTRALASIA. In this name we include Australia, New Zealand, Tasmania, and Fiji, all British colonies. But the term really covers more, for it includes islands not belonging to our nation. Australia was called New Holland by the Dutch, who discovered it in 1606. Austral means "south," so Australasia means really Southern Asia, but Australasia is a continent by itself.

EUROPE. The name of our own continent is derived from Greek words which mean "the broad face of the earth." Some scholars, however, believe that the name comes from a Hebrew word meaning "the land of the setting sun." The ancient people of the East knew very little of Europe, but they knew that the sun set in the west, and so might have called it the land where the sun set.

THE NAMES OF COUNTRIES

The names of most countries, new and old, contain a hidden story showing how people regarded the lands or their inhabitants at the time that the names were given. Let us glance at some of them.

ABYSSINIA. The syllable *ia* at the end of the name of a country is from the Celtic, and means land or territory. Therefore, Abyssinia means the land of the Abassins, or "mixed races."

ALGIERS is a newer spelling of the Arabic name *Al Jezair*, which means "the peninsula."

ARABIA. Here we have the *ia*, which tells us that Arab-ia is the territory of the Arabs, or men of the desert.

AUSTRIA. This name is a modern form of the big word *Oesterreich*, the name given to the country by Charlemagne. It meant Eastern Kingdom, and the country was so called to distinguish it from Charlemagne's empire in Western Europe.

BURMA. This is the English form of the word. The native name is written Mram-ma or Mianma, but it is pronounced Bam-mâ. Written, the name has the meaning of Mien, a Chinese title which Marco Polo found in use when he visited China six centuries ago. The word means

"those who are strong," and was, no doubt, formerly a title of a warrior caste.

CHILI. When the Spaniards arrived in the South American country which we now call Chili, they heard the natives give this name, which means cold, or "land of snow," to a certain cold part of the country, and so they wrongly applied the name to the whole 250,000 square miles.

CHINA. This is a name never heard in China, where names of various meanings are given by the people to the territories which make up their empire. We used to call China *Cathay*, but "China" is the name now used by English-speaking people. The word is believed to have come from *Tsina*, "the land of Tsin," the ruler who built the Great Wall of China.

ENGLAND. The name of our country really means "land of the Angles" or "Engles," the people who came over from Germany and conquered the country in the fifth century. England is still called *Angleterre*, which means *Angle land*, by the French. The Italians call our country *Inghilterra*, and the Spaniards call it *Inglaterra*.

FRANCE is the modern name of the country which was formerly called Gaul, a word shortened from the Greek name, *Gallatia*. The Gauls were the original possessors of the land, but the Franks, moving out of the German province of Franconia, conquered the land, and called it France or *Frankreich*.

GERMANY was formerly called *Inonges*, but the Romans borrowed a word from the Gauls meaning neighbours, and gave it a Roman form—*Germanus*.

HOLLAND is a modern spelling of *Ollant*, the Danish name, meaning "marshy ground."

INDIA means the country through which the River Indus runs.

IRELAND is "the land of the Irish," but the old name was differently spelt.

ITALY is the name given to the country once ruled over by a king named Italus.

JAPAN is a word never heard in the land itself. The Japanese name for their country is Niphon or Nippon, which means "land of the rising sun." Our word, Japan, is the result of a mistake made in spelling by early travellers to the East.

MONTENEGRO means *black mountain*, which is a noticeable feature in this mountainous country.

NEW ZEALAND. Tasman, the Dutch navigator, discovered New Zealand, and thought the islands so much like the Zealand at home in Holland that he called it the *New* Zealand.

PALESTINE means *the land of strangers*, the word coming from another word meaning "to wander." The country is called also the Holy Land, Canaan, and the Land of Israel.

PERSIA. The name the Persians give to their country is *Iran*. The name Persia was given to it as meaning *the land of the Parsas*, wild people so called, whose name really meant "the tigers."

PORTUGAL is a name which comes from *Portus Cale*. That was the name given by the Romans to the ancient city of Oporto. It meant "the port Cale," and from it the name of the whole country has sprung. The Portuguese call their country Portogal.

RUSSIA takes its name from the Russ, a tribe by which the land was seized long ago.

SAXONY is the name of the country from which our Saxon forefathers came. They took their title from the *Seax*, a short, crooked dagger with which they were armed.

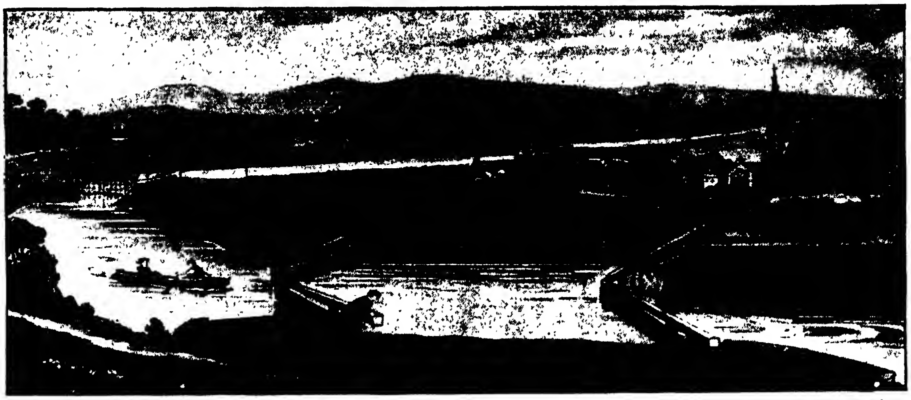
SCOTLAND was called Caledonia, it being then the land of the Caels or Gaels. In the third century, however, the Scoti, a tribe from the north of Ireland, overran the land, which came in time to take their name—Scotland, or "land of the Scots."

SPAIN. This is the English form of the Spanish name of the country, *Hispania*, or España. The name comes from an old-time word, "Span," meaning rabbit. The Carthaginians found the country overrun by these animals, and called the land after them.

WALES was formerly named Cambria, because people called the Cymri inhabited it. These people were never conquered by the Romans, and still kept together in Anglo-Saxon times, so that they became known to the English as Welsh, which means foreigners. Their country was called Wales, "the land of foreigners."

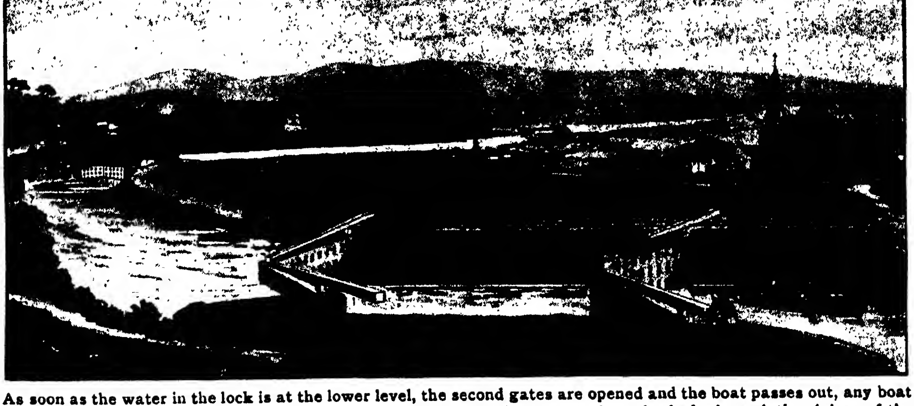
From all this we see that in the old times the names given to places had familiar meanings. The same system of fixing titles to towns, districts, rivers, and lakes may be traced when we look into the names preserved from ancient days in the interior of countries. Some of them are beautiful and poetic, particularly in the United States.

WHY A RIVER DOES NOT RUN AWAY



A river is ever running to the sea, and we may wonder, perhaps, why, in dry weather, all the water does not run into the ocean. In hot countries rivers do often run dry, and even in Britain a river may get too empty for boats to use. But to prevent this men build locks, which are doors to shut in the water. Here we see a river with its locks.

Each lock consists of a pair of gates with a space of river in between them. When a boat travelling down the river comes to a lock, the upper gates are opened, the second being kept closed. The boat passes in, and the water in the lock, which was at the upper level, is let out gradually through openings in the lower gate, as shown here.



As soon as the water in the lock is at the lower level, the second gates are opened and the boat passes out, any boat coming up-stream passing in. The gates are then closed. Water pours into the lock through the sluices of the upper gate, and soon the lock is once more at the higher level. The upper gates are then opened, and the up-going boat passes out. Lock gates point up-stream, as the pressure of the water running down closes them firmly.

WHAT WOULD HAPPEN TO A PENNY IF IT GOT BEYOND THE PULL OF THE EARTH?

The law of gravitation states that every portion of matter throughout the universe attracts every other portion of matter. Therefore, however far a penny were to go in any direction, it could never be beyond "the pull of gravitation." Wherever it was, it would be attracting, and attracted by, all the other matter in the universe, including the matter that forms the earth. But a penny might be imagined as going so far that the force of the earth's gravitation might not succeed in pulling it back, simply because the attraction of some other heavenly body was more powerful. If there were no other heavenly bodies, gravitation would, of course, have to bring the penny back to the earth, however far apart they were from each other.

Where the penny would go would depend on its direction. It might very likely be drawn into the moon. If it passed still farther away it might be drawn into the sun, or into Jupiter. But sooner or later it would almost certainly pass near enough to some large heavenly body, and be drawn into it. Its actual fate would depend on the force with which it left the earth in the first place, for if this were just right, the penny might travel round the earth as the moon does, or form a new planet revolving round the sun.

WHY DOES THE COLOUR RUSH FROM THE FACE WHEN WE ARE FRIGHTENED?

Plainly the reason why the face of a frightened person is apt to turn pale must be found in the circulation of the blood, which usually gives the face its colour. If at such a moment we had our finger on the large artery which beats at the wrist, and is generally called the pulse, we should notice that the beats had suddenly become few and feeble and irregular. That gives us the key to the facts. It is the heart that is beating too slowly, with feeble be 's not strong enough to force the blood along the arteries to the skin and other distant parts of the body.

We may wonder how fear can actually reach the heart and affect its action—so much so, indeed, as sometimes to stop the heart altogether, so that the person dies of fright upon the spot. The answer is, that there runs down the neck, on each side, from the brain to the heart, a remarkable nerve, called the *vagus*, or wanderer, because it goes to so many distant places, and one of its duties is to run to the heart and carry orders from the brain. These orders are always forbidding and negative, telling the heart to beat more slowly, and not so strongly; and when we turn pale from fear, what has happened is that the brain has sent powerful orders through the vagus nerve to the heart, nearly making it stop beating altogether.

WHAT MAKES PEOPLE FAINT?

When a person who has been standing up suddenly turns pale, sways, and falls to the ground, it is plain that something has happened to stop the working of his brain. Perhaps, when we are standing, we forget that our brain must be working all the time, and that if it stopped for a moment we should certainly topple over. And that is what happens when a person faints; the brain-centres which control the balance of the body, and those which give orders to the muscles of the legs, cease to act.

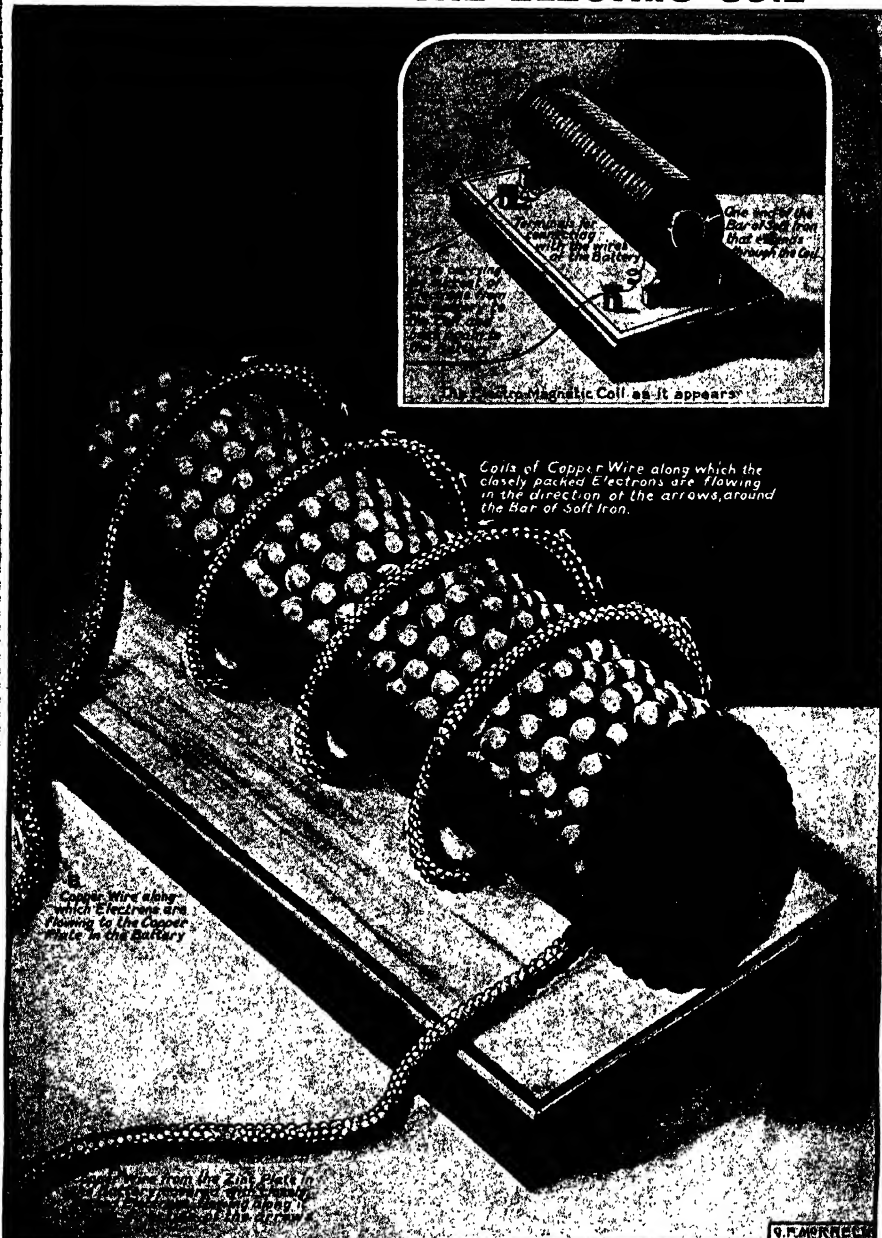
We can guess the reason of this if we remember that the face of a fainting person is always pale. This gives us the hint that the supply of blood to the head is defective, which is the true explanation. For some reason or other the heart is not sending enough blood upwards, and so not only the face but the brain, if we could see it, becomes pale and ceases to work. All nerve-cells require a continuous supply of blood, or they will cease to work. There is no other kind of cell that so quickly exhausts its nourishment and requires more.

Of course, we may go farther back and ask why the heart is not sending enough blood to the head. Many reasons are possible. Too much blood, for instance, may be going elsewhere, the heart may be weak or poisoned by our breathing foul air, or the blood may be too poor in quality to do its work properly.

WHERE DOES OUR WARMTH COME FROM?

As we talk of warm clothing we might think that our warmth, or some of it, came from our clothes; but, if we think a little, we shall agree that our clothes, at most, can only keep in the warmth, which comes from somewhere else. Sometimes, it is true, our bodies get warmth from something outside which is warmer than themselves—from the sun, or a fire, or in a hot bath. But we should be very badly off if we had nothing else to depend on for keeping up the heat of our bodies.

THE POWER IN THE ELECTRIC COIL



Wonderful as is the power of electricity, we could not make use of it for so many purposes as we do were it not for a simple contrivance called the electric coil, the working of which is explained in this picture. A bar of soft iron is wound round and round with a coil of thin wire, and when the ends of the wire, A and B, are connected with the battery, a steady flow of electrons takes place along the wire in the direction shown by the arrows. The progress of these electrons in some way disturbs the other electrons in or on the atoms of the bar of soft iron, so that the iron acquires the power of attracting certain substances and holding them tightly so long as the electric current is passing along the wire. When the current is broken the attraction ceases. *If a piece of steel on a spring is placed near either end of the iron bar, it will be pulled and released alternately as the current is joined and cut off, and so we get motion to ring a bell or work a telegraph. This piece of steel that works to and fro is called an armature.*

We make our warmth ourselves, and it all comes from our food. Almost everything we need as food can be burnt if it is dried, and, though it is certainly not dried in the body, it can be burnt there. The foods which burn best outside the body are those which furnish most of our warmth inside it. Such foods are fats and oils, sugar and starch. If necessary, our warmth can be got from the burning, inside the body, of foods such as meat and white of egg; but this is a very bad way of getting it, and, indeed, the reason why we take such foods as fat and sugar is to save the others and to supply the warmth of the body in the safest way. When we run and get hot we are burning up sugar and fat very quickly.

Of course, all burning requires oxygen, and half the credit of producing our warmth belongs to the air we breathe.

WHAT MAKES THE NEW ELECTRIC LAMPS SO BRIGHT?

We all know that during the last year or two the small electric lamps used in houses have become much brighter without costing any more to use. This is because a new kind of material has been employed in making them. In all these incandescent electric lamps, as they are called, the principle is the same. It is to send an electric current along a very thin wire which is kept away from the air. The wire is so thin that it offers great resistance to the flow of the electricity, much of which is turned into heat, and makes the wire glow. If the wire were exposed to air it would quickly burn away when made so hot, but the lamp is carefully made so as to contain practically no air, and if the glass is broken and admits the air the wire burns and snaps in a moment.

The brightness of the light depends largely upon the particular material of which the wire is made. The feature of the new lamps, now so much used, is that, instead of having a carbon wire, they have a wire made of one or other of three rare metals, named *osmium*, *tantalum*, and *tungsten*. But the supply of these metals is running out, and people are at a loss to know what to do next.

ARE HIGH HEELS HARMFUL?

No doubt many people wear high heels to their boots and shoes without being any the worse, yet it is a foolish habit, and sometimes may do real harm. The human foot is beautifully made for its purpose. It has a wonderful arch, which is elastic, and can give a little, and then rebound when pressure is placed upon it. This gives the spring and grace to the walk of people whose feet are in good order. But when people wear high heels they alter the line down which the weight of the body passes through the foot to the ground. Instead of passing down behind the arch of the foot, it passes through that arch and tends to fix it, so that people who wear high heels cannot walk naturally, and tire of walking much sooner than they otherwise would.

It is believed that, in some cases, people may hurt their brain and nerves slightly by wearing high heels, for every step means much more of a jar to the body for such people than if the shock were taken up by the spring of the foot. Then, again, people who wear high heels, and throw the weight of the body too far forward along the foot, are much less kind to their toes than they should be, and they are apt to have corns and ingrowing toe-nails, and to get the joints of some of the toes made very stiff.

DOES A FISH DRINK?

If any living thing is completely dried, it either dies or else it completely stops living until it gets water again. Therefore, every living being requires water, and this is true of a tiny microbe as it is true of ourselves. All living things must drink in one way or another. We know, also, that the water taken in is very quickly spoilt, and a fresh supply must be had; a man may go without food for forty days, but he cannot go without water for ten.

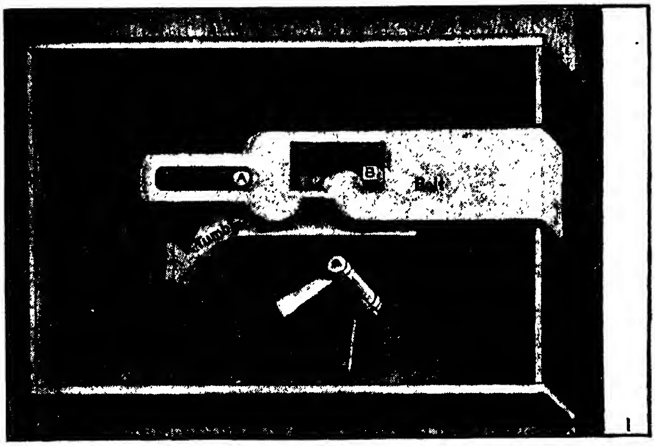
It is true, therefore, that fishes drink, and fishes that live in salt water must drink salt water. But we must not suppose that fishes are drinking when we watch them in an aquarium and they look almost as if they were gulping the water. Fishes require not only to drink but also to breathe, and as they live under water they must breathe by means of the oxygen which is dissolved in the water in which they live.

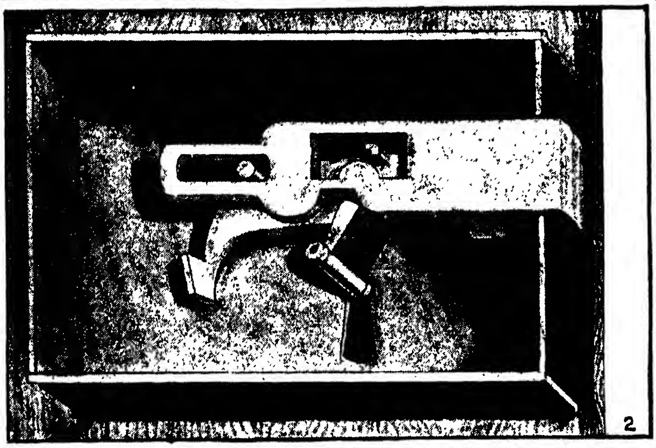
When we watch them they are breathing by passing water through their gills, which serve them for lungs, but are specially suited for breathing air that is dissolved in water. The water that passes through their gills yields up to their blood the oxygen they want, but this water is not drunk. When a fish drinks it takes water in by its mouth as we do.

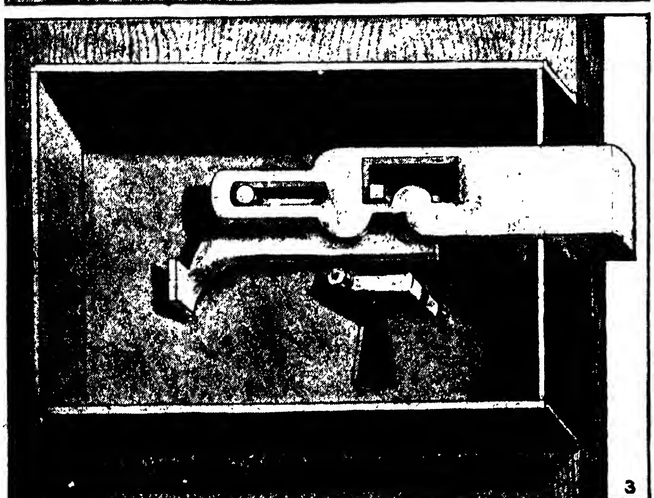
THE WONDER PACKED IN A TINY SEED

One of the mysteries that no man can explain is the way in which a tiny seed grows in a few months to be a beautiful flowering plant, eventually dying and providing more seed for the perpetuation of the species. Who put this beauty there? Who packed these tiny specks with the colour and wonder and fragrance of a lovely garden? At the foot of this page (from left to right) are shown the actual seeds of the scabious, the canterbury bell, the sweet-pea, the begonia, the gaillardia, the sweet-william, and the antirrhinum, and above them are the lovely blossoms that form out of these seeds.

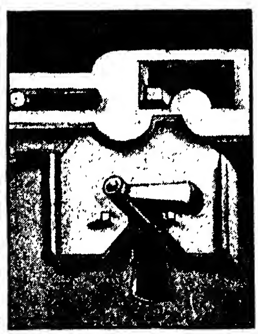
HOW THE KEY TURNS THE LOCK







Locks are as old as civilisation, and were first made of wood. It was in the reign of Alfred the Great that locks began to be manufactured in England, but there was little improvement in their construction until the end of the eighteenth century. Since that time there have been marvellous developments, until we have the elaborate and costly locks of the present day. Here we see how the common tumbler lock works. This is the ordinary cheap lock found on cupboards and drawers. As shown in this picture, a metal "tumbler" works on a pivot, A. A stud, B, projects from the tumbler and fits into a notch in the bolt, preventing the bolt from moving either way. But when the key is turned, as seen in picture 2, the "bit," or flat part of the key, lifts the tumbler and enables the bolt to be pushed along as seen in picture 3. As soon as the key is turned right round the tumbler falls, its stud fitting into a second notch in the bolt and holding it firm. Picture 4 shows the wards, or projections, which prevent any key but one specially cut to fit the lock from turning round, and in picture 5 we see how the right key can be turned over the wards.



THESE PICTURES SHOW THE INSIDE OF THE LOCK OF AN ORDINARY DOOR

WILL THE LAST MAN GASP FOR AIR?

It has long been thought that the oxygen of the air is being slowly used up, that the quantity of carbonic acid is increasing, and that in the long run the carbonic acid, which is comparatively heavy, will fill the valleys and low-lying places, so that men will have to climb out of them. And then, it might be supposed, the sea of carbonic acid would gradually rise, driving men higher and higher for the oxygen they need, until at last the number of men would get fewer, and the last man would die of suffocation, gasping for air somewhere on the side of a high mountain.

But usually we find that when something in Nature appears to be going all in one direction, or to be coming to an end, there is something else which compensates for it. Nature really moves in cycles, or circles, and one thing balances another. That is doubtless the case with the oxygen and carbonic acid of the air. When the quantity of carbonic acid tends to rise, the sea absorbs the extra amount, so there is no fear of our being forced up the mountain-sides; and the green vegetable world is always making new oxygen from carbonic acid. That is part of what is called the "balance of Nature."

WHY ARE ROSES RED?

This is a question which cannot be answered in a single sentence, for the redness of roses depends on many things, and not merely on the roses themselves. No rose is red in pure green light or in the dark; and in a pure red light a white rose is red. Plainly, therefore, we must study light as it reaches the rose from the sun.

We find that white light is a mixture including red. If any rose, or anything else that does not shine of itself, is lit in a light that does not contain red, that thing will not appear red. Roses do not shine of themselves, and therefore the first reason why roses are red is that there is red light in sunlight. But if there is red light in sunlight, why are some roses white and not all red?

The reason is that roses differ in their way of dealing with the sunlight that falls on them. Red rays, as well as all rays of other colours, fall upon a white rose; but it is not red, for it reflects to our eyes all the light that falls on it. As we have seen, if *only* red light falls on it it will be red, for it can only reflect that. But there is something in the red rose which causes it to behave differently with sunlight. Instead of reflecting all the rays that fall on it, it absorbs, or keeps to itself, all the rays that make up sunlight except the red ones. These it reflects to our eyes, and so we say it is a red rose.

WHY DO SOME THINGS BEND AND OTHERS BREAK?

This is a question which sounds as if it should be easy to answer, but really it is most difficult. All the questions about such things as bending and breaking, and stretching and brittleness, and so forth, are of the same kind, and the answers to them all depend upon a knowledge which we do not as yet possess.

We do not know what makes the parts of any solid thing stick together, and so we cannot possibly hope to explain such facts as bending, brittleness, or elasticity. We can, of course, study the effects of various outside conditions upon these properties, and we can learn something by studying such things as sealing-wax, which will readily bend at times, and will break at other times. In this case we find that the temperature of the sealing-wax makes all the difference; when warm it bends, when cold it breaks. This is true of many things.

Such facts as these help us a little way towards guessing the reasons why things behave in such various ways. The little parts, or molecules, that make them must be held together differently in different cases. In hot sealing-wax they behave as if they held each other with their arms relaxed, but in cold as if their arms were stiff. That is the only kind of idea we can form of this interesting question as yet.

IS THE BLOOD ALIVE?

As to whether blood is itself alive or not, the answer is both yes and no. Blood consists of a part which is certainly not alive, and of another part which is very much alive indeed. To our eyes, not helped by the microscope, blood is just a fluid, and a fluid cannot be alive. The fluid part of the blood is simply a mixture of a very large number of chemical compounds, food materials, salts, materials for poisoning

microbes with, materials which carry messages from one part of the body to another, and so on. These are not alive, though our lives depend on them.

But in this fluid there swim unthinkable billions of living cells, so that the blood is certainly alive to that extent. In the blood of a healthy man there are more than five millions of such cells in a quantity about equal to two pins' heads, and the blood of a healthy woman contains nearly five millions in the same space. These cells are of various kinds, red and white. The white cells are, perhaps, almost the most intensely alive of any cells in the body.

WAS THE EARTH ALWAYS 93,000,000 MILES AWAY FROM THE SUN?

ALWAYS and never are very big words, and people who use them often are more bold than they are wise. There was not always a sun, nor was there always an earth. Each had its beginning, and there can be little doubt that they began in much the same way and at much the same time. No one can realise how difficult this question is to study, until he begins to study it. Of late years we have begun to get clearer notions about it, especially because we have learnt so much about the other planets of the solar system, what they are made of, how hot they are, and what is happening upon them.

It seems probable that the earth was formed at about the same distance from the sun as we find that it is now. It would not be exactly the same distance, and, indeed, the distance must be slowly changing now; but it seems more and more likely that not only the earth, but the other planets as well, were formed in space from the great nebula that existed before the solar system, at something like the same distances as they occupy now. And at the same time the sun was being formed by the same laws, at a point which was—and still is—the centre of the whole.

WHAT HAPPENS WHEN WE BREATHE?

THE air is always pressing against everything and trying to get everywhere. When we breathe we make the chest bigger, and at the same time we open the chink between the voice cords, so that the pressure of the air forces some of it down into the lungs. Inside the lungs the air makes certain exchanges with the gases in the blood, so that when it is breathed out it is different in several ways from the air we breathe in. Breathed-out air contains much more carbonic acid, much less oxygen, and much more water than breathed-in air. It contains various waste particles derived from the inside of the lungs; and it is hotter than it was.

Until the last two or three years it was generally believed that the exchanges of gases between the air and the blood were just such as might happen from the two sides of, for instance, a thin piece of parchment or blotting-paper. But quite lately it has been proved that such an explanation is not enough. The changes that happen when we breathe could not be carried on without the help of the living cells that line the lungs. These cells are very flat and thin, and it used to be thought that they did nothing but allow the gases to pass through them; but now we know that they pick and choose what shall pass and what shall not. This is the latest discovery in the science of breathing

WHAT MAKES COLOURS IN THE FIRE?

LIGHT is made of waves in the ether. Different waves make light of different colours. The waves are made by the movement of the parts of the atoms of the thing that sends forth light. Different atoms are differently made, and the "electrons" that make them, move in different ways. Therefore, different atoms produce different kinds of waves in the ether, which means that when they produce light at all, the light is of different colours. We know altogether about ninety different kinds of atoms, and each of them produces a different light. Also the same kinds of atoms may produce different kinds of light at different temperatures, because when the atoms are heated they move differently.

So now we see that the different colours produced in the fire are due to the various kinds of atoms that are present there at various temperatures hot enough to make them give forth light. Coal contains many elements, and thus a coal fire has many colours. Glowing carbon is red. The yellow flames are due to the atoms of the element sodium. If we see a violet flame it is due to the element potassium; and there is a blue flame produced by the atoms of a gas which is called carbon monoxide.

IF TREES GROW FROM SEEDS, HOW DID THE FIRST SEEDS GROW?

This is really another version of the old question: Which came first, the hen or the egg? The answer is that the egg came first, and the answer to our present question is that the first oak tree grew from an acorn, but the first acorn was a new thing in the world, not produced by an oak, though doubtless by something very like an oak.

There are constantly coming into the world of life new seeds from which grow kinds of living things which are more or less new. They vary from those which went before them, and so they are known as variations. The first egg that produced the first hen was a variation, and so was the first seed that produced the first tree. Of course, we do not expect such changes to be very violent. We should not expect a fern to produce an acorn one day, or anything but a bird rather like a fowl to produce the egg from which a fowl grew. Still, these new things do keep on coming into the world, and all progress depends upon them, for, in many cases, the new kinds are superior to the old, and once the new variation has been produced, its descendants will be of the same kind. The great question is, *how* do the new kinds of living things get started, and this problem is now being slowly explained by careful observation and study.

WHERE DOES ALL THE ENERGY GO AFTER A FOOTBALL MATCH

This question has been wisely asked by someone who knows that all kinds of energy or power must always be accounted for, as they can never be lost. First, we must observe where the energy is after we have kicked the ball. It is in the motion of the ball, and, as it cannot be destroyed, we can readily understand the first law of motion, which says that the ball will go on moving in the same straight line for ever at the same speed, unless something stops it.

Therefore, we must find what stops the ball, and then we shall be able to trace the energy which the kick first put into it. The ball is stopped by the resistance of the air and by the friction as it rolls along the ground. This means that its energy is now to be traced in the movement and heating of the little particles of air which it disturbs, and in the movement and heating of the ground. Of course, the ground must be heated a little, just as our hand is when we rub it on our clothes. In this way the ball gradually spends its energy, and ceases to move. If we trace the energy in the other direction, we soon find that we are led back to the sun—which really kicked the football, as it really performs every act of every living being.

CAN COAL-GAS ESCAPE FROM GRAVITY?

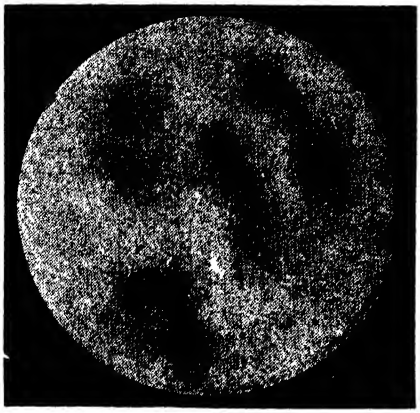
Nothing is more certain than that the law of gravity is always acting. It is never disobeyed or destroyed or suspended, because, though that may happen to the laws of men, it can not happen to the laws of Nature. Therefore, if anything appears to be defying the law of gravity, we must be sure that really it is under the influence of some other force or forces, and that what happens is the result of those forces and the law of gravity as well.

This is the case with a floating balloon or a floating cork, with an airship or a sea-ship, with a mountain and the clouds round its summit. It applies to coal-gas also, and if coal-gas or any other gas rises, we must understand that gravity is acting on it all the time, and that without gravity it would behave very differently.

A most remarkable discovery has lately been made, that it is possible for the atoms of any gas to jostle each other, and that in this jostling a certain number of them may move so fast that the gravity of the earth is not sufficient to hold them. When this happens these atoms fly away into space, though even as they do so, they are as much under the influence of gravity, and as much affected by it, as if they were falling back to earth. This especially applies to small globes, and explains why the moon has no atmosphere.

WHAT IS THE BLOOM ON A GRAPE?

The bloom on a grape is very beautiful and delicate, and we value it because it tells us that the grape has been cared for since it was plucked; or, if we see it on grapes that are growing, we value it there because we think of it as the right thing in the right place. Like the bloom on a cucumber, the bloom on the grape is really no part of the grape at all, nor can we even say that it is made by the grape. It is really a mass of microbes that have gathered upon the skin of the grape.



When we say that we see a man in the moon we mean that the shadows seen in the left picture look like the eyes, nose, and mouth of a man; but in the right picture, showing the moon through a telescope, our artist shows how we may get a much clearer image of a man in the moon by merely emphasising a few lines that really exist.

WHO IS THE MAN IN THE MOON?

FANCYING that we see faces or figures in the moon is rather like playing the game of pictures in the fire. It teaches us the power of imagination, and enables us to understand how much our own brains contribute to everything we see. At times we can certainly imagine that we see a great face in the moon, though we change as we grow older, and the writer of these words, who used to see the face very clearly when he was a child, has not seen it for many years—probably because he is always looking for something else, and has other ideas in his head when he looks at the moon now.

At any rate, there is no doubt that there are markings on the moon, and that in proportion to the moon's size they are very large, and many of them very high. We can prove that they are so by measuring the length of the shadows which they throw upon the moon's surface when the sun's light catches them sideways. These markings are partly what we must call mountains; they are partly, perhaps, in the nature of creeks, or clefts, and the most remarkable and beautiful of them look like craters of huge volcanoes. These are very large and have very high sides, as we can see when the sun shines sideways upon any of them, because then one side of the wall of the crater is brilliantly lit and the other is in deep shadow. It is these craters, above all, that help us to see the man in the moon, or the little old woman gathering sticks, or whatever else people have thought they could see there.

There remains, however, a deeply interesting question which astronomers are now studying keenly. Are these craters really craters, and was the moon's surface really once covered with gigantic volcanoes? Some argue that things are indeed what they seem on the surface of the moon, and that the volcanoes are so big because the moon is so small. That sounds curious, but the explanation is that the moon, being small, would cool very quickly, and if it cooled very quickly and shrank very quickly its volcanoes and its moonquakes, as we might call them, would all be on a big scale.

But other astronomers are beginning to say that perhaps these markings never were volcanoes at all. They argue that the moon has no atmosphere to act like a great protective blanket or like the armour-plate of a ship, as our atmosphere does, and that the effect of meteorites, or shooting stars, falling upon the moon would therefore be very serious. They argue that, at a certain stage in the moon's

history, when its surface was much softer than it is now, pieces of rock, or whatever we like to call them, flying about in space and striking the moon at a tremendous rate might produce those effects which we now imagine to be craters. If this is true, the "marks" are not really craters at all, but are mighty scars, or holes, punched in the moon, like the holes punched in armour-plate by shells shot from a great gun.

HOW DOES A GYROSCOPE WORK?

A gyroscope is very like a top. Indeed, it is only a very heavy and carefully-made top. It usually takes the form of a wheel with a heavy metal rim, and this is held or enclosed in such a way that if it is set spinning it can do so freely. Of course, any spinning thing tends to slow down, owing to the resistance of the air and the friction where it is supported—unless, like the earth, it does not spin on anything. So by various means a gyroscope may be made to go on spinning, and then we can observe its behaviour in all sorts of conditions.

It has quite lately been learnt by men of science that mere motion will give resistance and force and all the properties of hardness and rigidity to things which had not these properties before. And this is true of the gyroscope. Its spinning motion gives it the power to resist very firmly anything that tends to alter the direction of its spin. The heavier the gyroscope, the greater will be the amount of motion in it when it spins, and the greater its resistance to any force that tries to alter the direction of its motion.

Therefore, a railway carriage may run safely on a single rail without tilting over, simply because it carries a spinning gyroscope, spinning so fast and made so heavy that its tendency not to be disturbed or tilted will completely prevent the carriage from tilting, and make it safer, perhaps, than if it ran on two rails.

WHY ARE CHILDREN FOND OF DOLLS?

Some people have said that children are not really fond of dolls because they are dolls, but simply because they are possessions. These people declare that the secret is to be found in the liking which children have to possess things, just as grown-up people have the same liking, and that children will get quite as fond of anything that is theirs as of a doll.

But those who really know anything of children know a great deal better than this. They know that, as a rule, a child, at any rate during several years of its life, is far fonder of a doll than of anything else, and that if the child has the chance to nurse a real baby, that is better still. So the truth is that the love of dolls is really the mother-instinct and the father-instinct showing themselves already, even in little girls and boys. This is a wholly beautiful thing, and should never be laughed at.

Often little boys are told that they should not play with dolls, but with soldiers. One little boy, who had not been taught such nonsense, had his doll out with him in the street, and some big boys cried out and jeered at him. But the little fellow had a good reply. He turned round and said, "None of you will ever be a good father."

WHY DOES A HEN CACKLE AFTER LAYING AN EGG?

Of course, this is not an easy question to answer, for we cannot ask a hen why she cackles, and indeed, if she could speak, she would not give a reason; for this act, like many of our own, is not a reasonable one, but simply a consequence of the way in which a hen is made. It is what is called an instinctive action. Yet we can understand it because we can compare it with actions of other creatures about which there is no doubt.

The doing of anything which we were meant to do gives us pleasure. The bodies of living things are constructed in this way, as we might well expect. Now, pleasant feelings in ourselves and in other creatures often excites the body to some kind of activity, as when we say that a person sings for joy. When we feel very pleased with ourselves we want to sing, or whistle, or dance, or do some such thing. It is a question of what is called the expression of the emotions. A dog has the advantage of us in one respect, because it has a tail, and when a dog is pleased, it not only gives a special bark, which is its way of singing for joy, but it also expresses its emotion by wagging its tail. On the other hand, an angry lion will sway its tail from side to side, and express its anger in that way.

So when the hen cackles after laying an egg, it is simply her way of singing for joy. Her body and her feelings have the satisfaction of having done something which her body is meant to do. It is probable that the actual laying of the egg causes a little discomfort, and there is a

corresponding feeling of ease and satisfaction when the task is finished.

If we want to learn more about this subject in general, we should read Charles Darwin's famous and fascinating book called "The Expression of the Emotions in Man and Animals."

WHAT ARE "BLIND-ALLEY" OCCUPATIONS?

A blind alley is a road along which one can gofor a certain distance, and then no farther. We have to go back and make a fresh start, and we have lost all our time. And so we now give the name of "blind-alley" occupations—a name which every boy should know—to those which seem to offer a road to somewhere, but lead a boy nowhere, waste years which he can never regain, and perhaps even destroy his power to learn something better afterwards.

All who have studied the subject know how important this question is, and boys and girls should all be warned in time of the consequences of going into a "blind-alley" occupation. A boy leaves school at fourteen, and can at once get employment which brings in a few shillings a week, but which teaches him nothing. For instance, this may be the case with telegraph boys, to take a case where the State itself has been to blame. After a few years, when the boy is beginning to become a man, and to expect a man's wages, he is, instead, turned off to make room for a younger boy. Since his "blind-alley" occupation has taught him nothing, and has only given him time to forget what he learned at school, he has to seek unskilled and poorly-paid labour, and often can get no work at all. Many scores of thousands of boys and girls in England are now in these "blind-alley" occupations, and the time is come when we must put an end to a process which causes so much harm. It injures the boys and girls themselves, and it afterwards only too often makes them a burden upon the nation instead of part of its real wealth.

DOES A POKER IN FRONT OF THE FIRE MAKE THE FIRE BURN?

The answer to this question is almost certainly that the poker makes not the least difference! The truth is that it would require very delicate and often-repeated experiments to decide a question like this, and the ordinary careless kind of observation proves nothing at all, for who can say how well or ill the fire would have burnt if the poker had not been there? The poker is always used before it is stood up against the bars, and there lies the secret of its success, as people would soon find if they tried standing it up without poking the fire first.

WHY CAN'T LIGHT TURN A CORNER?

There are several ways in which light can be made to turn a corner, but it is true, and it is one of the most important facts about light, that it naturally travels in straight lines. This does not mean that the light from a lamp travels only in one direction. It travels equally in straight lines in all directions, and since it is a property of light to travel in straight lines, of course it cannot turn a corner by itself.

But fortunately there are many ways in which light can be made to turn a corner, for there are many ways in which rays of light can be bent or turned. By means of a mirror, or any surface which reflects light at all, light can be made to turn a corner, or any number of corners, so long as at each there is placed a reflecting surface. In just the same way, of course, a ball can be made to turn a corner, though a ball has the natural tendency, like light, to move in a straight line, according to Newton's first law of motion.

Light can also be readily made to turn a corner by what is called refraction. This is the name given to the bending of a ray which in passing from one thing to another, as from air to water, or air to glass, becomes, as it were, cracked.

WHAT IS A CYNIC?

The word cynic is simply the Greek for *dog-like*, and means a person who has rather a snarling and dog-like kind of temper; at least, that is supposed to be the origin of the name. The great argument of the cynics in ancient Greece was that men must give up luxury and beauty, and even cleanliness, and any kind of decent human comfort. As we can imagine, they were not pleasant people, though it cannot be denied that they showed much courage and suffered much discomfort. One of the most famous of the cynics, pretending to be very humble, used to show himself in a cloak full of holes—a perfect instance of what has been called "the pride that apes humility." This particular cynic lived in the time of Socrates, who said to him, "I see your vanity peeping through the holes in your cloak."

WHY THE NELSON COLUMN DOES NOT FALL

THERE is not a man of science in the world who can explain how it is that the towering column in Trafalgar Square does not fall. No man, indeed, can explain why you can lift the whole length of a poker by merely grasping and raising the handle of it

You are reading this, no doubt, in a room somewhere, and nobody can tell you why that room stands. Men can measure the depth of the sea and the distance of the sun; they can calculate the weight of the earth itself, and can tell what will happen in the sky in a hundred years; but no man can explain why the roof of your house does not fall upon your head. It is not enough to say that the wood and iron are fastened together, that the bricks are held fast by mortar, and that great beams hold up the roof, for every tiny atom of matter that makes up bricks and mortar and wood and iron is flying about like snowflakes on a windy day. Nothing is what we call "solid." Every bit of matter flies about at a rate that we can hardly think of—specks so small that each single speck has as much space to move in—in proportion to its size—as the earth itself; and they fly about, as we know, in a world that is itself for ever flying.

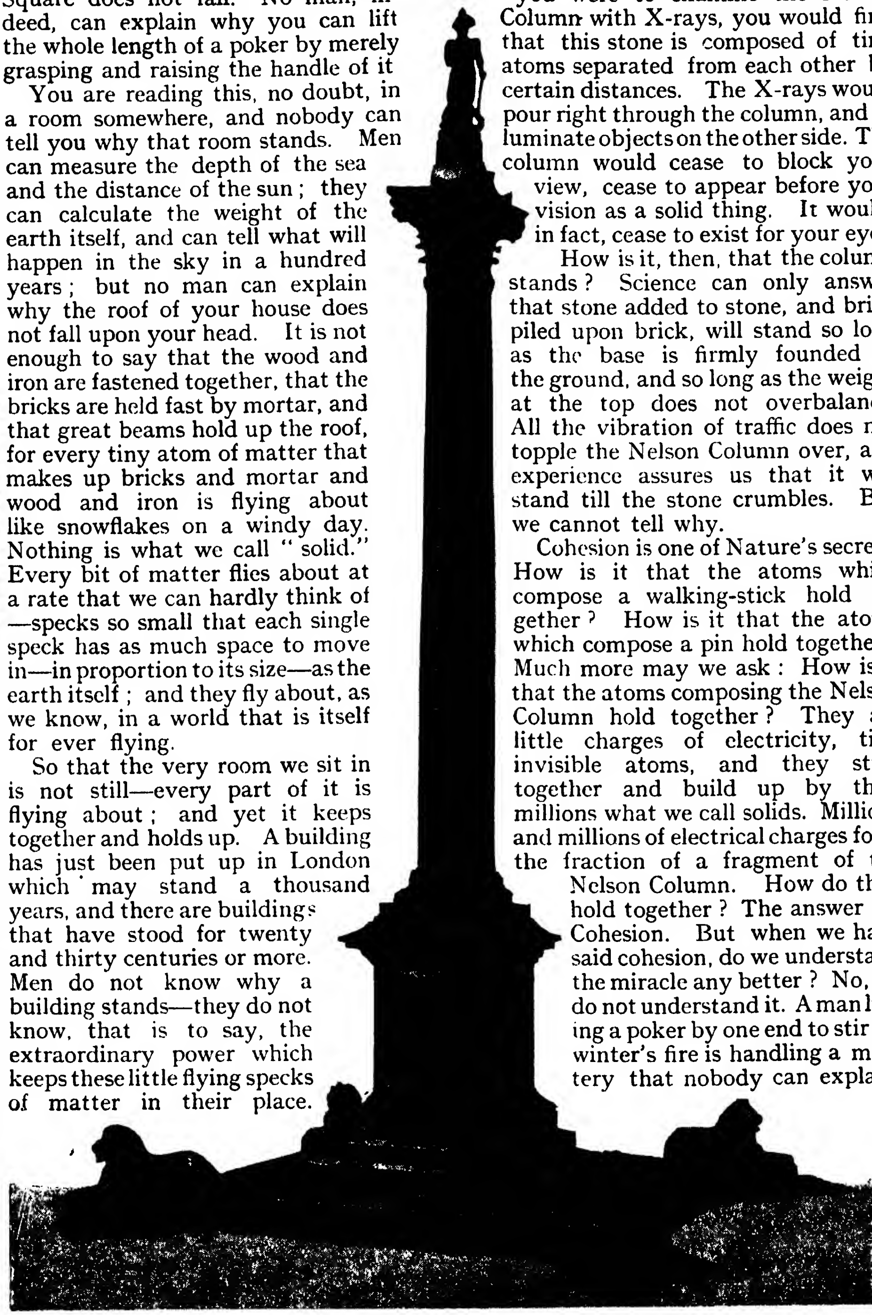
So that the very room we sit in is not still—every part of it is flying about; and yet it keeps together and holds up. A building has just been put up in London which may stand a thousand years, and there are buildings that have stood for twenty and thirty centuries or more. Men do not know why a building stands—they do not know, that is to say, the extraordinary power which keeps these little flying specks of matter in their place.

There is a name that stands for this mystery, but that is all we know. It is what we call the miracle of *cohesion*.

If you were to examine the Nelson Column with X-rays, you would find that this stone is composed of tiny atoms separated from each other by certain distances. The X-rays would pour right through the column, and illuminate objects on the other side. The column would cease to block your view, cease to appear before your vision as a solid thing. It would, in fact, cease to exist for your eyes.

How is it, then, that the column stands? Science can only answer that stone added to stone, and brick piled upon brick, will stand so long as the base is firmly founded in the ground, and so long as the weight at the top does not overbalance. All the vibration of traffic does not topple the Nelson Column over, and experience assures us that it will stand till the stone crumbles. But we cannot tell why.

Cohesion is one of Nature's secrets. How is it that the atoms which compose a walking-stick hold together? How is it that the atoms which compose a pin hold together? Much more may we ask: How is it that the atoms composing the Nelson Column hold together? They are little charges of electricity, tiny invisible atoms, and they stick together and build up by their millions what we call solids. Millions and millions of electrical charges form the fraction of a fragment of the Nelson Column. How do they hold together? The answer is: Cohesion. But when we have said cohesion, do we understand the miracle any better? No, we do not understand it. A man lifting a poker by one end to stir his winter's fire is handling a mystery that nobody can explain.



WHY THE WINDS BLOW

THE GALES THAT SWEEP ACROSS THE SEA

When we look at a weather-vane we can tell from what direction the wind is blowing. The revolving part of a weather-vane has much more surface at one side than it has at the other side. The result of this is that the side with the bigger surface is blown away as far as it can be blown by the wind. Thus the smaller part is at the side from which the wind is coming. Arms are generally fixed to the stem of a weather-vane, and at the end of these arms are the letters N., S., E., W., indicating the four directions of north, south, east, and west. If the arrow of the vane or the head of the weather-cock points to north, the wind is blowing from the north.

It is easy enough to read the weather-vane, and, if we think a little, the weather-vane will perhaps suggest quite a number of other questions.

Why, for instance, does the wind blow at all? Why does it not always remain perfectly still, as it does sometimes on a fine summer evening? Why does it sometimes blow gently and sometimes strongly, and sometimes rage in a winter hurricane? Why does it blow sometimes from the north, sometimes from the south, and sometimes from the east or west? Finally, why do some kinds of wind bring some kinds of weather, and other kinds of wind bring other kinds of weather? The answers to all these questions will provide us with the causes of wind and its conditions.

The science of wind and weather is called *meteorology*. The word comes from two Greek words meaning "to raise beyond." The word *meteor* now means only a fragment of stone from another world that comes flying through space into our atmosphere. But formerly the word meteor had a much wider meaning. Anything connected with the atmosphere was called a meteor, and so the science of the weather became known as meteorology.

Now we come back to the first question: Why does the wind blow? The answer might take this form: For the same reason that smoke comes out of a chimney. That may seem a curious answer, but it is correct. The real cause of the wind is that air expands and rises as it becomes hotter. If we take an empty bottle, stop its mouth with a cork, and place it in front of the fire, what will happen? After a while either the cork will pop out or the bottle will burst. The air inside the bottle has become hot and wants more room.

Now, the sun shines upon this world and heats the air in certain parts. The warmed air, being lighter than cold air, rises; and cold air, being heavier than warm air, rushes in to fill up the place

which the warmer air occupied before it began to rise. That is the reason why the wind blows, given as simply as it can be given. But the reasons are more complex than that simple statement.

Generally, a breeze from the sea begins to blow on to the land a few hours after the sun has risen. Again let us ask—why? Land becomes warmer than water under the heat of the sun, so the air on the land rises, and the cooler air from the sea blows in to take its place, only to be warmed in its turn, and to allow more cool air to blow in from the sea. When the sun has set, the land gets cool more quickly than the sea, so that the air above the land is denser, or heavier, than the air above the sea, and the cooler land air blows out to sea to replace the warmer sea air that is rising because it is warmer.

WHY ARE SOME WINDS WARM AND SOME COLD?

Winds become like the surface of the earth over which they travel. A wind blowing over a hot, dry desert becomes hot and dry; a wind blowing over ice-fields and snow-clad mountain-tops becomes piercingly cold; a wind blowing from, or over, the sea is apt to bring rain. Let us think a minute about the winds that blow in the British Isles. A south-west or west wind in summer has come from the warmer regions on the other side of the Atlantic Ocean, so it is warm, and, as it has crossed the ocean, it brings rain. A wind from the east has come over the countries of Central Europe, and is not likely to be so rainy. A wind from the north-east has come from Northern Europe, within the Arctic regions, and is sometimes bitingly cold.

Whatever wind may blow, it has its cause in the inequality of temperature and heaviness in the atmosphere. Nature strives for equality, and warm breezes and cold blasts are Nature's way of equalising matters.

WHAT ARE THE TRADE WINDS?

The trade winds are so called because, in the days before steamships, these winds were really the "drivers" of the world's trade, being the only power which enabled the ships to travel along the great highways of the ocean. The trade winds are winds that are always blowing from the Poles towards the Equator. But in going towards the Equator the trade wind that comes from the Arctic regions does not blow directly south, and the trade wind that blows fr m the Antarctic regions does not blow directly north.

The reasons for this are interesting. The earth is always revolving, carrying the air along with it. Thus the air at the Poles is revolving with the earth and at about the same rate as the parts of the earth near the Poles are revolving. As the winds proceed towards the Equator, they go always into parts of the world that move faster than the parts near the Poles, just as in top-spinning the widest part of the top moves more quickly than a spot nearer the centre.

The winds that have come from nearer the Poles do not at once acquire the faster speed, so that the earth beneath them revolves faster than they do, and therefore they come to be not north and south winds, but north-east and south-east winds. The trade winds are most pronounced in the Pacific and Atlantic oceans, because there is almost no land surface to modify them in their passage.

WHAT IS A WHIRLWIND?

We do not experience the whirlwind, or tornado, in this country as the inhabitants of other countries do. The whirlwind is caused by winds coming from opposite directions at the same time. When such winds meet, they make a circular motion with great violence, and, being pressed on by more wind coming behind, may be driven upwards with such force that at sea they may draw up a column of water with them, thereby making a waterspout.

At times terrible gales sweep the sea. Before the days of steamships sailors used to look forward with dread to the autumnal gales. To them the roaring winds perhaps meant death. Often they would battle with the elements for days together.

The sails would be torn to shreds by the fury of the wind. The mighty, foaming seas would charge upon the ship like an invading host, throwing themselves with terrific force upon the decks, and sometimes carrying away the masts. Although the gales are still violent, they are not such a danger to shipping as they once were, for nowadays liners and steamships are independent of the wind for their motive power, and so they plough their way doggedly through the boisterous sea until they reach the desired port.

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